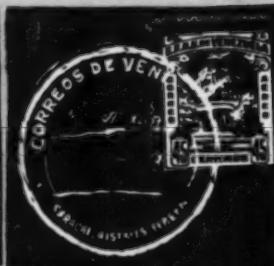


MINING ENGINEERING

JULY 1952



WILFLEY

centrifugal PUMPS

30 acres 2 miles

- **Wilfley Special High Head Sand Pumps** play an important role in the successful reclamation program of the Hawaiian Commercial & Sugar Co.
- Each year, at the Puunene Mill, 30 to 40 acres of useless, sandy waste land are transformed into productive ground for sugar cane cultivation.
- Soil, removed from mechanically harvested cane by washers, is settled to a sludge of 15% to 25% solids. This sludge, together with a sludge of repulped filter cake, is pumped to the diked waste area. When dry, there remains a 2 to 3-ft. layer of reclaimed cultivable topsoil over the coral sands.
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Denver, Colorado, U.S.A.
New York Office: 1775 Broadway,
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to the famous
WILFLEY
Acid Pump

Upper: Reclaimed land under cultivation.

Center: Diked reclamation area.

Bottom: Waste land to be reclaimed.



MINING ENGINEERING

Incorporating Mining and Metallurgy, Mining Technology and Coal Technology
VOL. 4 NO. 7

JULY, 1952

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Manager of Publications
Editor, Mining Engineering

CHARLES M. COOLEY
Associate Editor

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N. M. VITULLO M. E. SHERMAN
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Assistant Editors
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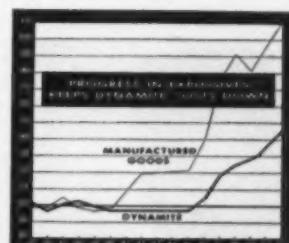


Chart shows relative stability of dynamite prices since 1935, as compared with prices of other manufactured goods, 1935-39 values=100.

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See our four-page insert in the Mining Catalog.

Letters to the Editor

Not Self-sufficient, But Largest

One item of general interest in **MINING ENGINEERING Trends**, May 1952 gives the wrong impression of the scale of the ilmenite operations in North Carolina. It also implies there are known deposits of rutile which "guarantee self-sufficiency for many years." So far as we know this is not true. At present, rutile is in such short supply in the United States that the Defense Mineral Authority is encouraging prospecting for new deposits. So far none have been found of any consequence and our needs have to be met largely from the deposits near Jacksonville, Fla., and rutile imported from Australia.

**JAY P. WOOD
VICE-PRESIDENT
HUMPHREYS GOLD CORPORATION**

The reference to self-sufficiency was meant to apply to the ilmenite-bearing sands, not rutile, but improper phrasing failed to make this clear. However, the press release that the Glidden Co. circulated stated that this deposit of ilmenite was one of the largest in North America.—Editor

Pennsylvania Tackles Stream Pollution

You will recall my article on **Municipal-Water Needs vs. Strip Coal Mining**, MINING ENGINEERING, May 1949.

Some of the points made therein included the following: Removal of top soil and its later replacement over the strip-mine operation; all acid-forming materials, shale, clay, subsoil at bottom of pit; compaction of subsoil so replaced; contouring of ground after pit filled to get natural drainage and good run off; and planting of trees and grass on the replaced top soil.

The Pennsylvania Sanitary Water Board has recently shown sufficient faith in this approach to elimination of acid mine water in strip coal mining to issue rules for the guidance of mine operators as an experiment to see if the approach works. These rules include the preceding plus the following: Limit exposure of coal to 500 ft; do not let rain water accumulate in pools; drain or pump out all sources of underground water instead of blanketing it out as suggested in my article; and compacting the subsoil in layers of 4 ft replaced. The experiment is worthwhile if Pennsylvania is to have clean streams in the vicinity of strip-mine operations.

GEORGE M. DEXTER
32 FENIMORE ROAD
SCARSDALE, N. Y.

We wish to thank Mr. Dexter for his letter giving details of the action of the Pennsylvania Sanitary Water Board. It is always interesting to have details of concrete action which highlight theories presented in articles and transactions—Editor.

Pre-testing in Lab ELIMINATES GUESSWORK for Projected Process

PROBLEM ...

A mining company wanted to know if lightweight aggregate could be produced profitably from material available in a company-owned shale deposit.

"Can a product be made that will meet commercial aggregate specifications?" And — "Will the process be commercially practical?" The customer wanted answers to these questions before going ahead with full-scale operations.



WHAT WAS DONE ...

A sample from the shale deposit was sent to the Allis-Chalmers Process Research Laboratory. Tests in the Laboratory's 15-ft rotary kiln and gyratory crusher indicated that the product would meet the highest aggregate standards . . . and that the process would yield a healthy margin of profit.



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A-3675



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—Personnel Service—

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., New York 18; 100 Farnsworth Ave., Detroit; 57 Post St., San Francisco; 84 E. Randolph St., Chicago 1. Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for \$3.50 a quarter, \$12 a year.

MEN AVAILABLE

Executive Engineer, 37, married, 3 children. Now Resident Manager nonmetallic underground mine and processing plant. Management and operational experience in gold, copper, zinc, limestone and lime products manufacture. Mine plant design and construction, underground mines and quarries. Excellent references. Currently employed but available reasonable notice. Prefer U.S. M-687-426-E-5-San Francisco.

Metallurgical Engineer, 29, married, one child, B.S. Metallurgical Engineering. Five years' practical experience in milling and laboratory research. Available thirty days. Prefer West or Southwest U.S.A. M-689-522-E-1-San Francisco.

Experienced Mining Engineer, university graduate, 40, married. Twenty years' experience all phases metal mining, past 13 years as manager; excellent cost and safety record. Available short notice. Best references and complete professional record available upon request. M-690.

Mining Engineer, 47, married, recent geology graduate, with supervisory experience underground and quarries, seeks western states position establishing residence. Current and past two years' employment was minerals exploration and development with both field and office studies. Varied productive background, has sustained health and interests. M-691.

POSITIONS OPEN

Director of Engineering for an engineering institute, 30 to 40, with Doctorate in mining, chemical, electrical or mechanical engineering. Must have good experience in research, preferably industrial, and a good teaching record. Salary, \$6000 to \$7000 a year. Location, South. Y7166.

Geological Draftsman, 25 to 30, with some experience in working with a geologist. Salary, \$5100 a year. Location, New York, N. Y. Y7153.

Assistant Chief Engineer, about 40, with experience in mining and/or chemical plant operations. Should have experience with shovels, hydraulic grinding and classifying. Salary open. Location, Florida. Y7109.

Research and Development Engineer to lead program directed toward concentration and recovery of minerals from nonferrous ores. The existing facilities are principally concerned with electro-static and electromagnetic separations and milling and classifying operations. Should have ability to plan and execute a program with the above objectives in mind. Should have sound technical training, with a few years' experience in research and development work in this field, and preferably some production experience. Location, Pennsylvania. Y7091.

Mining Engineer experienced for three mining enterprises located in the U. S. (a) Mining Engineer for a zinc and lead mine in Colorado. This is a shaft operation and will require reworking of the old shaft. Will require installing all necessary equipment for mine camp, etc. Eventually a concentration mill. (b) Mining Engineer for gold-silver mine in the State of Washington. Some up-raise development work must be done. Mill will be installed to produce bullion when metallurgical process has been worked out by top-rank metallurgical engineers. (c) Mining Engineer for silver-gold prospect in Idaho. This is a shaft sinking job with levels run at proper intervals to develop ore tonnages. Salaries open. Y7088.

Mill Superintendent with some experience in nonmetallic minerals, particularly diatomaceous earth. Salary open. Location, Washington State. Y7075.

General Manager, 35 to 45, with at least ten years' mining or construction, plant engineering and industrial management experience in Latin America. Salary, \$12,000 to \$15,000 a year plus bonus. Location, South America. Y6882.

Chief Warehouse Superintendent, 35 to 50, with at least ten years' industrial and mining equipment experience, to supervise inventory records, schedule purchases, plan economical handling of receiving, shipping of machinery, tools, parts, materials, foods, consumer goods, etc. Salary, \$8000 to \$10,000 a year. Must speak Spanish. Location, South America. Y6784.

Mining or Metallurgical, graduate, not over 28, with degree in mineral dressing engineering, preferably with one or two years' experience in the milling of metals for sales contact

work. Prefer single man. Salary, \$4800 to \$5400 a year. Location, New York, N. Y. Y6494.

Engineers. (a) Mine Foreman with at least three years' underground experience for lead-zinc operation. Salary, \$4800 a year plus housing and family accommodations. (b) Shift Boss preferably engineering graduate, with underground experience. Salary, \$4200 a year plus housing and family accommodations. Must speak Spanish. Location, Peru. Y6679.

Mining Engineers. (a) Assistant Superintendent, graduate mining engineer, young, with three to five years' experience in underground supervision; experience in cut and fill stoping desirable. Single status preferred. Three year contract. Salary, \$5580 a year. Altitude, 13,500 ft. (b) Chief Engineer, graduate mining engineer, with three to eight years' experience in surface and underground surveying, drafting and ore reserve calculations, planning of surface and underground installations. Three year contract. Salary, \$5700 a year. Altitude, 13,500 ft. Location, South America. (c) Assistant Mill Superintendent, graduate metallurgist preferred, with considerable milling experience in base metals. Should be first class maintenance man to supervise repairs in mill. Salary, \$6000 a year. Location, northeast of continental U. S. Y6530.

FOR SALE: Diamond Core Drill Rig. Sullivan wheel mounted complete rig—\$2,500. A bargain.

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The U. S. Atomic Energy Commission needs experienced geologists in its Division of Raw Materials in both domestic and foreign positions. Salaries—\$5060 (GS-9), \$5940 (GS-11), \$7040 (GS-12), and \$8360 (GS-13), depending on experience. Minimum experience three years. Civil Service status not required. Those interested should write to U. S. Atomic Energy Commission, 70 Columbus Avenue, New York 23, attention Robert D. Nininger, Div. of Raw Materials.



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McDonald, Ohio, slag dump.

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powered by GM 3-71 Diesels. Allis-Chalmers
HD-5 tractor powered by GM 2-71 Diesel.

PERFORMANCE: Each of the engines in the
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date without overhaul.* 3 Euclids
hauling to crusher handle 2100 tons
per 10-hour day on 500 to 1000-yd.
haul cycles. *Piston rings
replaced in 3 engines at 10,000 hours.



THIS DIESEL has worked 11,000 hours without overhaul

McDonald, Ohio, is a slag dump
operated by the U.S. Steel Company.
It is located in a valley about 10 miles
from the Ohio River. The dump is
about 1000 feet long and 1000 feet
wide. It is about 1000 feet deep.



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JULY 1952, MINING ENGINEERING-629

Body Hoists

A complete new line of hydraulic dump truck body hoists and bodies featuring many outstanding design improvements has just been announced by St. Paul Hydraulic Hoist. Fourteen models of this new hoist are available in a selection of capacities from 6 to 25 tons. The new body hoist features low standard mounting height; advanced lifting point; new low operating oil pres-



sures; a new Uniflex subframe; friction-free roller bearing drive mechanism, including pump and power takeoff, to insure quiet operation and long trouble-free life. A stress-eliminating design feature of the new hoists absorbs dumping shocks and permits use of a new principle in hoist design . . . a flexible subframe which ends tendency of rigid hoists to crack or bend when flexed. **Circle No. 1**

Combination Drill

A new combination drill offering all three methods: rotary, auger, and percussion drilling on the same rig is the revolutionary feature of the latest drill rig designed by Mobile Drilling Inc. The B-36 drill is larger, more powerful and versatile than previous models built by this company. This new drill has a hydraulic feed of approximately 8000 lb pressure. The hydraulic feed cylinder is located directly over the rotary turntable. The carriage of the drill is of tubular construction. The drill mast, also of tubular construction, nests in the tube members of the drill carriage for cross-country travel with a maximum overall height of 10 ft. The drill mast telescopes together with the feed cylinder hydraulically to an operating height of 16 ft. The drill can be furnished with an auxiliary cut head, sand reel, and special high pressure water pump. The B-36

maximum depth for auger drilling without water is approximately 150 ft; depth for rotary drilling with water is in excess of 300 ft. **Circle No. 2**

Replaceable Cutter

Of interest to operators of clamshell buckets in the excavating and heavy rehandling field is a new reversible and replaceable cutter recently announced by Blaw-Knox Co. The new unit replaces the old type, one piece tooth presently used. Similar in principle to the two-part tooth used so successfully in draglines and trenchers, the new tooth consists of a base which is permanently attached to the scoop, or lip, in the usual manner, and a reversible and renewable tip which fits into a slot and wedges itself into the base. Replaced in a fraction of the time required to install old style teeth, the new unit not only reduces costly shut-down time but further effects savings by requiring only the replacement of that portion of the tooth which wears out. **Circle No. 3**

Stripper Shovel

Several models of the new hi-lift stripping shovel recently introduced by the Koehring Co. are working in various sections of the country. Using the same base machine as the standard 2½ cu yd Model 1005, the hi-lift stripper operates with a 50 ft boom and 36 ft dipper stick. This attachment allows a maximum dumping height of 40 ft and a reach of 60 ft with boom angle at 45 degrees. By comparison, the standard 1005 shovel attachment, operating by chain crowd, carries a 26 ft boom and standard 19½ ft double dipper



sticks for heavy-duty digging work. Features of the new hi-lift design include a single dipper stick with cable crowd and a twin box section boom structure for maximum strength and minimum weight. Unusually large sheaves are employed throughout to prolong cable life. **Circle No. 4**

Belt Conveyor

A new conveyor belt capable of unloading a full carload of coal in one minute has been installed by the Rail-To-Water Transfer Corp. The

belt is 72 in. wide and 942 ft long. It is designed to handle 3000 tons of coal per hr, an increase of 50 pct over the 54-in. belt formerly used. The belt, furnished by the mechanical goods division of United States Rubber Co., is made of 7 plies of 42-oz duck with a 1/4 in. rubber cover on top and a 1/16 in. cover on the pulley side. **Circle No. 5**

Slusher Block

Sauerman Bros., Inc. have enlarged their line of Durolite tempered steel sheave-blocks by adding a block designed essentially for slushing, mucking and wrecking duty. This block resembles the standard Durolite blocks in its general specifications. Sheaves and frame are of differential heat treated alloy steel. Swivel fittings are quick opening and free moving. A bead cast in the frame protects rim of



sheave, prevents fouling of cable. Important new features are: wider, flatter sheave groove to permit use of larger cable than standard block of same diameter; extra wide throat opening to pass knotted cable; lighter weight than other blocks of similar capacity, making for easier handling in tight places. **Circle No. 6**

Drill Bit

A new bit that drills brittle coal at fast rates of penetration is now offered by Kennametal, Inc. Faster drilling is obtained by reducing the amount of surface contact of the cutting edge at the bottom of the hole. Also, steeper clearance angles are provided to minimize bit drag. The new design is said by users to penetrate at the rate of 10 to 20 pct faster than the conventional all-purpose bit. The latter bit offers a balance between speed and long service life and can be used more universally. **Circle No. 7**

Free Literature

(8) CRUSHER: The American AC type rolling ring crusher is described fully in the newly revised 8-page bulletin just released by the American Pulverizer Co. Handy, informative tables for domestic stoker and commercial screenings in which are tabulated such pertinent data as speed, capacity, horsepower, weight and dimensions for the entire AC series of American coal crushers, are given in this booklet. Another feature in this booklet is a report from twenty-nine coal mines and power plants in which American AC's are installed—an independent survey based on more than sixty-one million tons of American-crushed coal. Photos are given of typical American crusher installations in the mines, power plants and central stations of America.

(9) CASTERS: A newly-revised 36-page caster and truck catalog covering an expanded line of equipment has just been published by the Rapids-Standard Co. This 2-color fully-indexed catalog has photos and complete specifications on casters and wheels designed to handle light, medium, or heavy loads on all types of floor surfaces. Shown for the first time in the catalog are the new 43 series caster models, combining low cost with durability for medium duty industrial use. Also introduced is the new line of V-Trac casters for use either on inverted angle-steel tracks or on flat floor surfaces.

(10) PIPELINE STRAINERS: A new 4-page bulletin just off the press describes the complete line of Anderson self-cleaning pipeline strainers made in sizes from $\frac{1}{4}$ in. to 3 in. An interesting discussion titled, "Value of Sediment Control" points out the numerous pieces of pipeline equipment needing strainer protection. These include steam traps, reducing valves, air tools, pumps, temperature regulators, etc. In addition, the bulletin contains complete specifications and prices on the product. *The V. D. Anderson Co.*

(11) MINERAL JIG: The Yuba mineral jig is a self-contained unit consisting of cells, screen baskets, and a completely enclosed package drive. Jigs are shipped from the shop completely assembled and test-operated to assure alignment of all components. They can be furnished for various types of installation; cross-flow or end-flow with the drive on either feed end or discharge end of the unit. Jigs are made in two, four, or six cell units depending upon the arrangement desired. These jigs are rated at between 25 and 30 cu yds per hr (35 to 45 tons) per flow line of one or more cells in series. Construction details of the mineral jib are designed to ensure a unit that will give maximum service with minimum upkeep. Screen baskets

and grids are coated with rubberized paint to minimize abrasion and corrosion, and at slight additional cost the inside walls of the hatches also can be rubberized. *Yuba Mfg. Co.*

(12) MOVING AIR: An improved device for moving large volumes of air quickly and economically in situations requiring intermittent or emergency ventilation, is described in a new 4-page bulletin published by Mine Safety Appliance Co. Portable and light-weight, the instrument is adaptable for use in industrial plants, mines and wherever else circumstances make it necessary to remove air contaminants from confined areas or to introduce fresh air for safe ventilation or rapid cooling. The bulletin gives examples of its use in oil refineries, chemical companies, steel plants, mining operations, etc.

(13) REBUILDING PLANT: Just published is a 6-page bulletin on the Ashland Division of National Mine Safety Co., a new plant devoted exclusively to the rebuilding of Joy Mining equipment. Designed for multiple unit production, with definite delivery dates for finished work, this plant is located at Ashland, Ky. Illustrated in the bulletin are some of the typical rebuilding operations which will be done in the 43,000 square foot plant.

(14) FLOOR DRILL: Cincinnati Lathe & Tool Co. offers a new catalog, D-110 illustrating and describing the C-O Cincinnati 14 in., 3000 sliding head floor drill with exclusive tilting motor bracket for easy speed changes. The spindle is made of high alloy steel, accurately machined; the six-spined spindle is mounted in two double-shielded ball bearings and housed in a ground

steel quill. Simplified speed changes and uniform belt tension are provided for by a unique tilting motor bracket. Speeds are changed merely by tilting the motor bracket and shifting the belt. No wrenches are needed. The column is cast in one piece and dovetailed ways for the sliding head and round table are cast integrally with the column and hand scraped to an accurate fit.

(15) DUST CONTROL: The Pungborn Corp. offers a 28-page two-color bulletin describing dust control and its many applications. Case histories of users of this equipment are documented with photographs and performance data indicating savings achieved through the installation of dust control equipment. Specifications on sizes and dimensions of equipment are listed as well as construction details. Application and engineering data are tabulated according to types of dust, and collection requirements. It is possible to determine the probable requirements for a dust collection system from the engineering tables.

(16) SOIL SAMPLING: This new bulletin represents a complete collection of data and information about soil sampling techniques accumulated during the past thirty-three years by the Acker Drill Co. Modern sampling techniques are discussed along with recommendations as to correct tools and accessories best suited for economical recovery of samples. One of Acker's popular soil samplers is a tube split lengthwise and held together by a ball check head and a hardened shoe. To operate, the sampler is forced into undisturbed earth by either jacking, hydraulic pressure or light driving. The ball check prevents washing out of the sample.

Mining Engineering

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July

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"Bedeviled Copper" helps to build a battleship

• The hard, ductile, malleable metal known as NICKEL derives its name from "kupfer-nickel", meaning *bedeviled copper*, a name given it by superstitious medieval Saxon miners. These miners, in uncovering what appeared to be a fresh lode of silver ore, thought the devil of the earth, "Old Nick", had cast a spell over their ore since it could not be hammered into useful articles . . . and it was several hundreds of years later that Cronstedt's discovery led to the actual recognition of nickel.

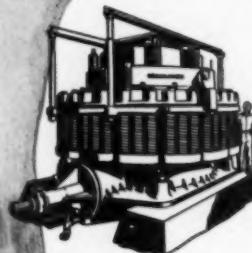
Among the thousands of ways in which nickel now serves man is in the construction of a modern battleship—where this versatile corrosion-resistant metal is used in armor plate, gun tubes, and scores of other ordnance, navigational and communications material.

From the opening of the first Sudbury mine in 1886, the history of nickel is largely that of International Nickel Company, who today produce fully 75% of the world's total nickel output. Playing an important role in International Nickel Company's production are twenty "SYMONS" Cone Crushers . . . which are recognized throughout the world for their ability to efficiently produce a great quantity of finely crushed product at low cost.

Thus, through the 20 "SYMONS" Cone Crushers at "Inco" mines passes the majority of nickel used today . . . one more example of a job well done by "SYMONS" Cones.

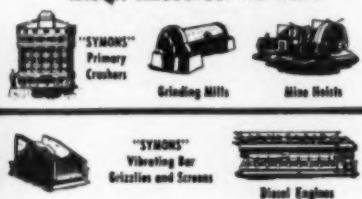
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Steel

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The changing pattern of progress, West of the Mississippi and East of the Rockies, is readily traced through the pages of Sheffield history.

First products of record were produced in 1888 to meet the needs of the great railroad building expansion. Following the rail lines came the fabulous development of agriculture, construction, mining, highways, manufacturing, oil and ship building. Each of these facets of industry presented needs for steel in different shapes and forms. In meeting such kaleidoscopic requirements, the Sheffield organization acquired a vast accumulation of skills, techniques and facilities and, today, produces a wider diversity of steel products than any other similar steel making set-up in the country.

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Fast and Powerful New Plate Mill—Fabricators of such steel products as pressure vessels, processing and storage tanks for liquids and gases, transportation line pipe, etc., require plate steel in far greater quantities than the slow cumbersome plate mills of yesteryear could produce. A new, powerful, 4-high plate mill at Sheffield's Houston works now rolls white hot slabs into long lengths of steel plate in a matter of minutes for shearing into sections to meet fabricators' needs.



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MEET THE AUTHORS

Howland Bancroft (*A Modern Approach To Foreign Mineral Development*, P. 666) was born in Denver, Colo. and attended the University of Colorado, University of Michigan and received a B.S. and B.A. degree. From 1907 to 1912 he was with U. S. Geological Survey. In 1911 he was involved in study of mining resources of Peru. Mr. Bancroft resigned from Federal Survey and opened offices as consulting mining geologist in Denver in 1912. From 1919 to 1920 he was a consulting engineer in San Francisco. He was manager of Sinclair Panama Oil

Corp. in Panama City in 1920. From 1921 to 1923 he was vice president and managing director of same corporation. He did independent examinations in Western states and an exploration trip through Turkey in Asia from 1924 to 1925. Mr. Bancroft was vice president and general manager of Lago Petroleum Corp. in charge of operations in Venezuela. Mr. Bancroft has spent time in 34 different countries in the world and in a number of different Latin American States, Europe, Asia Minor and Africa.



D. M. DAVIDSON

D. M. Davidson (co-author with G. M. Schwartz) was born in Quincy, Ill. and attended the University of Minnesota. He received a B.A., M.S. and Ph.D. degree. He graduated with a *Magna Cum Laude*. From 1928 to 1939 he was a geologist, chief geologist and senior engineer with Selection Trust Ltd. of London, England. Mr. Davidson has been vice president and director, E. J. Longyear Co., Foshay Tower, Minneapolis since 1939. He was visiting lecturer in mining and geology at Columbia University in 1948 and 1949. Mr. Davidson was consultant to: U. S. Corps of Engineers, U. S. Bureau of Mines, President's Materials Policy Commission and Materials Metals Reserve and War Production Board during World War II. Besides holding membership in AIME, Mr. Davidson is a member of American Association for the Advancement of Science, Canadian Institute of Mining Engineers, Society of Economic Geologists and Institution of Mining and Metallurgy, London. Mr. Davidson has presented numerous papers before the AIME. Fishing, ornithology and photography are his favorite pastimes.

R. W. Storey (co-author with Newell) was born in Greensburg, Pa. and attended Lynch high school in Lynch, Ky., and the University of Kentucky. He received a B.S. in chemical engineering. Mr. Storey has worked for Lehigh & Navigation R. R. Co. in Middlesboro, Ky. and Louisville, Ky. for three years. For one year he was employed by the Clinchfield Coal Corp. at Dante, Va. as mine engineer. He was employed by U. S. Coal and Coke Co. at Lynch, Ky. as assistant engineer in charge of field corps. At the present time he is connected with Consolidation Coal Co. in Jenkins, Ky. where he resides. An AIME member, fishing is his favorite hobby.

E. F. Reed (*Deep Prospect Drilling at Miami Tiger and San Manuel, Arizona*, P. 682) was born in Winfield, Kansas and attended Colorado School of Mines and Columbia University. He received a E.M. and M.A. degree. From 1923 to 1925 he worked for various mines in Western United States. Mr. Reed was employed as an engineer with American Smelting & Refining Co.



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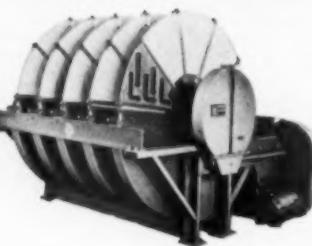
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ENGINEERS



MEET THE AUTHORS Cont'd



E. F. REED

from 1925 to 1927. He was chief engineer and geologist with Andes Copper Mining Co. in Chile from 1927 to 1942. From 1942 to date he has been geologist with Anaconda Copper Mining Co. at Inspiration, Ariz. An AIME member, problems related to ore deposits are of special interest to him. Besides holding AIME membership, he is also a member with Society of Economic Geologists. Photography and square dancing are his favorite pastimes.

G. M. Schwartz (*Geologic Setting of the Copper-Nickel Prospect in the Duluth Gabbro Near Ely, Minnesota, P. 699*) was born in Oakfield, Wis. and attended University of Wisconsin. He received a B.A., M.A., and Ph.D. degree. Mr. Schwartz was a field geologist with the Wisconsin Geology Survey and from 1916 to 1918 he was a geologist with Copper Range Co. He was instructor, professor and director of Minnesota Geological Survey, at the University of Minnesota between 1919 to 1952. An AIME member, he also holds membership in Geological Society of America, Society of Economic Geologists and American Mineralogical Society. Hunting and fishing are his favorite pastimes.

J. P. Newell (*Experiments with an Underground Auger, P. 677*) was born in Huntington, W. Va. and attended Maysville high school and the University of Kentucky. He received a B.S. in mining engineering. Mr. Newell has been employed by the Consolidation Coal Co. in Jenkins, Ky. in engineering dept., making time studies, experiments with underground auger miner and is now working as section foreman. Golf in his favorite pastime. Mr. Newell resides in Jenkins, Ky.

R. J. Mechlin (*The Lead Mining Outlook in North Africa, P. 675*) was born in St. Louis, Mo. and attended the Colorado School of Mines. He received an Engineer of Mines degree. Mr. Mechlin has worked in Mexico, Arizona, southeast Missouri, and northern New York as mucker, manager and vice president. He is associated with St. Joseph Lead Co.

H. Rush Spedden (*Adsorption of Sodium Ion on Quartz, P. 693*) was born in Colville, Wash. and attended Lewis and Clark high school and University of Washington. He re-

ceived an M.S. degree from the Montana School of Mines. From 1940 to 1942 he was a research assistant and instructor with Massachusetts Institute of Technology. Mr. Spedden was production specialist with U. S. Foreign Economic Administration in Bolivia from 1942 to 1944. From 1944 to 1946 he was with U. S. Army Corps of Engineers. At the present time he is assistant professor of mineral dressing at the Massachusetts Institute of Technology. An AIME member, he has presented previous papers before our society: "Flotation Microscopy of Cuban Manganese Ores" with A. M. Gaudin and "Attachment of Mineral Particles to Air Bubbles in Flota-

tion" with Mr. Hannan. A resident of Winchester, Mass., photography, canoeing, skiing and camping are his favorite pastimes.

A. M. Gaudin (co-author with H. Rush Spedden) has presented numerous papers before the AIME. Mr. Gaudin attended Columbia University and Montana School of Mines. He received an E.M. degree from Columbia in 1921 and an honorary Sc.D. degree from Montana School of Mines in 1941. At the present time he is director of Massachusetts Institute of Technology's research laboratory. Fishing, painting, photography and collecting stamps are his hobbies.

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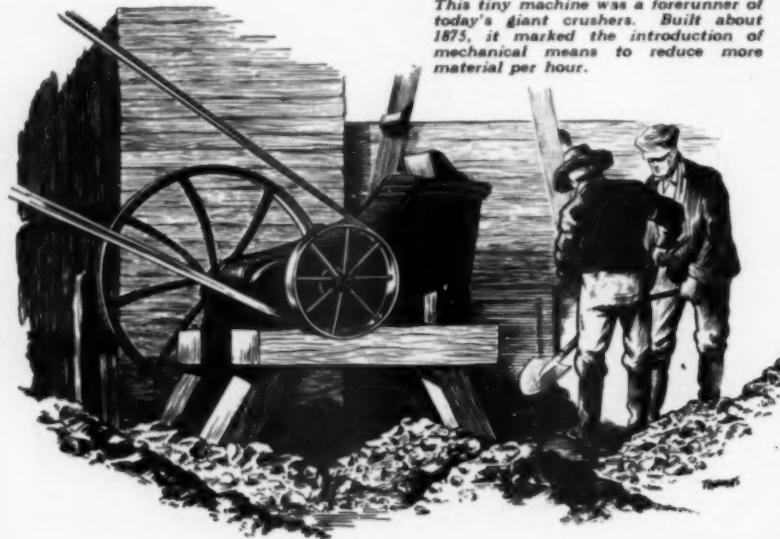
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Step by step, little machines and crude inventions have been developed into powerful, more efficient equipment to keep pace with the needs of a growing nation. For 50 years, Traylor has made it a policy to *lead* in the development and production of better machinery for the mining industry. In that time, mining men have come to depend on the skill and experience of Traylor to supply them with the tools they need. They know that when they consult Traylor, they consult experience . . . half a century of it.



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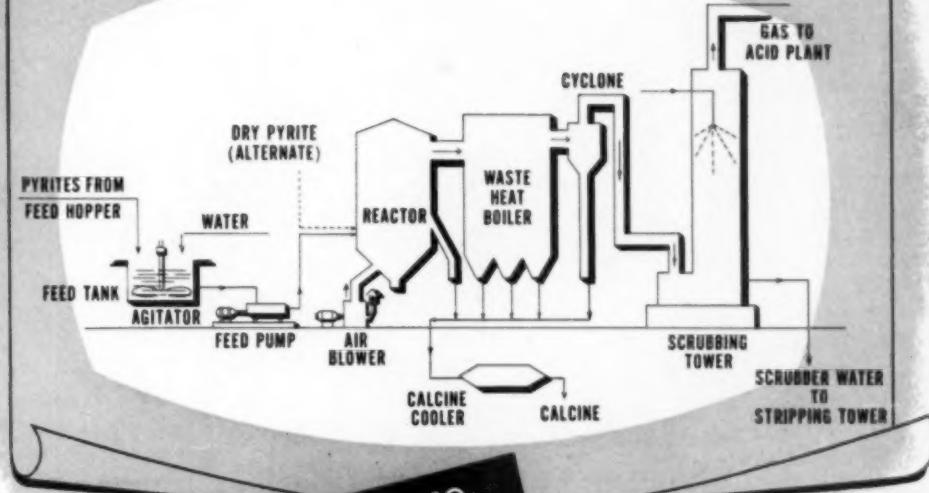
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and accurate temperature control
from sulphide roasting
... with the Dorrc FluoSolids System.*

Sulphuric acid manufacturers faced with a shortage of elemental sulphur are finding in FluoSolids an economically feasible means of tapping sulphides as an alternate source of SO₂. Fifteen FluoSolids Systems are now under construction to furnish SO₂ gas for contact acid plants.

For detailed information about FluoSolids — a distinct departure from conventional roasters — ask for a copy of Dorrc Bulletin No. 7500. Just write to The Dorrc Company, Stamford, Conn., or in Canada, The Dorrc Company, 80 Richmond St. West, Toronto 1.

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Gas Strength will average 10-15% SO₂ from pyrite and other sulphides.

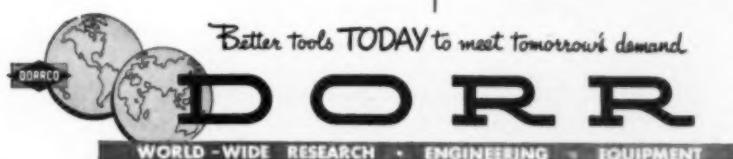
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Low Maintenance because no moving parts are exposed to high temperatures.

No Extraneous Fuel Needed once calcining temperature is reached.

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Freedom is on the march!

The freedom America celebrates on the Fourth of July has a special significance to anyone in the Western world whose life work in mining or metallurgy has contributed to our ever-increasing supply of strategic minerals.

But freedom to march resolutely ahead must be—and now is—amply possessed of the metal sinews with which to defend its security and expand its benefits to all.

To help achieve this end, Cyanamid has devoted over three decades of research to product and process development and application—first in Cyanidation, then in Froth Flotation, and latterly in Processes for Separation by Specific Gravity Differences.

Consider iron ore, the cornerstone of our industrial civilization.

Tremendous new bodies of high-grade ore have been discovered and are being developed. But, equally important, beneficiation of lower-grade ores by Heavy-Media Separation, the Dutch State Mines Cyclone Separator and Froth Flotation is indefinitely prolonging the economic life of the Range and opening new vistas for beneficiating iron ore deposits world wide. Witness results recently reported on fine-ore beneficiation (1/4" x 65 mesh) at a western Mesabi concentrator using two 12" Dutch State Mines Cyclone Separators capable of treating 125 tons per hour. Concentrate from feed containing 48.6% Fe and 26.5% SiO₂ assays 60.0% Fe with SiO₂ as low as 10.1%, a practical duplication of heavy-liquid results with power consumption and medium loss acceptably low.

Equally noteworthy advances are being made in base-metal and non-metallic concentration. New reagent combinations and better treatment methods (alone and in combination with Processes for Separation by Specific Gravity Differences) are expanding the output of such strategic minerals as antimony, chromite, cobalt, industrial diamonds, fluorspar, manganese, molybdenum, sulphur, tin and tungsten.

Specialized reagents — such as Aerofloat 226 and 213 and Cyanamid 400, 600 and 800 Series Reagents — added to traditional reagent combinations are helping to produce higher grade concentrates at economic costs, particularly in the treatment of oxidized lead ores and complex sulphide ores. New Cyanamid Reagents and processes in advanced stages of development promise to provide unique new methods for increasing recoveries of strategic minerals.

To help you capitalize on these developments, we have prepared resumes of current practice and avenues of approach to better beneficiation. These special technical bulletins are practical guideposts to progress in solving beneficiation problems. They are offered without obligation, as a preliminary to discussion with Cyanamid Field Engineers, located in all important mining districts. The Cyanamid Mineral Dressing Laboratory staff is also available for consultation on your particular problems.

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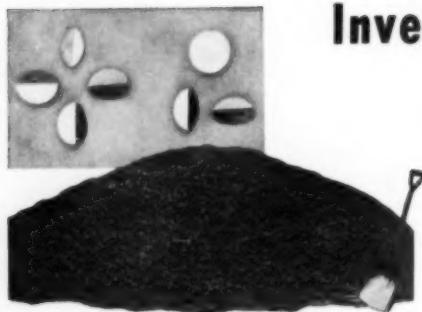
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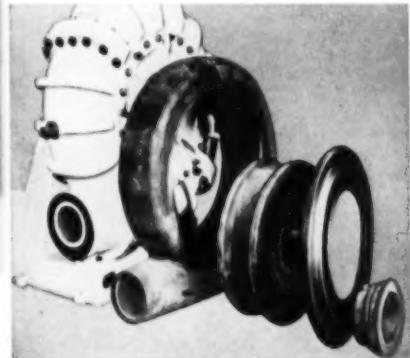




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THESE BALL MILL LINERS of chilled NI-HARD replace rolled steel liners for milling ores. The user previously used all types of liner materials, including manganese steel, chilled iron, etc., before standardizing on NI-HARD.



SOLIDS-HANDLING PUMP PARTS, produced to take full advantage of NI-HARD, include impellers, shell liners, suction side liners, engine side liners, throat and seal rings.



Investigate NI-HARD for your ABRASION PROBLEMS

NI-HARD is produced by
authorized foundries from coast to coast

NI-HARD® . . . an abrasion-resisting nickel iron . . . has proved the answer to hundreds of problems involving severe abrasive wear. During the past 20 years it has set notable records for length of service, down-time saving and *ultimate economy* where wear-resistance is the primary requirement. A few typical NI-HARD applications are illustrated.

At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, nickel is obtainable for the production of NI-HARD for many end uses in defense and defense supporting industries. There are authorized foundries, from coast to coast, equipped to produce NI-HARD castings in all common forms and shapes.

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Tesaloy Foundry Co.
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THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK 5, N.Y.

The Office of Price Stabilization broke the copper price loggerhead between the U. S. and Chile when it permitted copper wire and brass mills to add to their ceiling prices 80 pct of the increase in cost of foreign copper above the 27½ cents per pound specified in the agreement with Chile.

Another step forward in the processing of taconite seems to have been made with the patenting of a process for the strengthening of taconite pellets. The patent was issued to Fred D. De Vancy and assigned to the Erie Mining Co., of Hibbing, Minn. Strength of the pellets is improved by adding from one to five pounds of starch or sodium silicate.

A new iron ore deposit discovered on Vancouver Island will start producing soon, and is expected to yield 2 million tons of magnetite over its span of operation. A new mill will be built by the Argonaut Construction Co., of San Francisco, at the deposits of the Utah Construction Co., its parent organization.

The Organization for European Economic Cooperation banned the use of nickel and nickel alloy in the manufacture of about 500 products in an attempt to conserve nonferrous metals in short supply. Some 18 members of the organization have already volunteered to restrict nickel consumption.

The aluminum development at Kitimat, B. C., has placed Canada in the front ranks of the world's aluminum producing countries, according to F. L. Lawton, chief engineer of Aluminum Laboratories, Ltd. He noted that of Canada's total production, Canadians use only 15 pct.

Reconstruction Finance Corp. has been negotiating with several Bolivian tin operators for their tin now piled up at several South American ports. A few of the smaller operators are reported to have accepted a price of \$1.215 per pound, the price paid to other producers. The effect the recently announced Bolivian Government monopoly on all mineral sales will have on the negotiations is not clear.

American manganese buyers have entered into a contract with the South African Minerals Corp., providing for 27½s per long ton plus 48 pct manganese ore, compared with the previous price of 25½s 6d. American manganese producers are said to be investigating the possibility of erecting a \$840 million smelting and refining plant in South Africa.

International Nickel Co., is reported to be negotiating purchase of some 5000 acres of nickel and copper-bearing lands south of Ely, Minn. The company has been exploring the area, and if investigations prove the deposit mineable, it may result in Minnesota's first nickel and copper mine.



AMSCO dippers keep the heat on loading at 50° below zero

North Pole weather plus loading "pure rock" are no problems to Manganese steel dippers.

In June, 1948, an iron mine in the northwestern Adirondacks installed its first AMSCO dipper. It's still going strong—16 hours a day, 7 days a week! Old type dippers used previously lasted as little as one week. And the mining company had to employ four welders full time to keep them going.

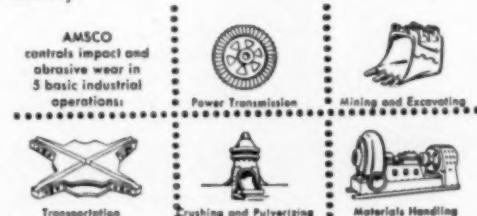
In design, too, AMSCO dippers are made for the type of punishment low grade ore and low temperatures inflict. Except for tooth work, the only repair has been the replacement of the heel band after two-and-a-half years of this kind of vigorous operation.

Of course, not all mining and excavating operations are as tough as this one . . . but it's

a good example of how to save money and manpower through the use of AMSCO products.

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Other Plants: New Castle, Del., Denver, Oakland, Cal., Los Angeles, St. Louis. In Canada: Joliette Steel Division, Joliette, Que.
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Hanna Pilot Plant Operating in Michigan On Low Grade Ores

The Hanna Coal & Iron Corp., pilot plant at Randville, Mich., is handling about 250 tons of low grade Michigan ore daily. Ore is obtained from an open pit near the plant.

Operating alone in the area, the project was first announced about a year ago. Construction began June, 1951 and actual testing started about the first of the year. A paper presented by Plant Superintendent Elton P. Geist at the Upper Peninsula AIME spring technical session, described the plant and outlined the present flow sheet.

A two-step beneficiation scheme is presently being used. It utilizes both flotation and gravity methods. After crushing and grinding to 28 mesh, the ore is passed over Humphreys spirals, making a coarse iron concentrate. Tailings from the spiral concentrate are then reground and floated to produce iron concentrate and a final tailing. Geist stressed that the present flow sheet is tentative and one of several possible variations.

Testwork is continuing at the plant and future work will determine the method of agglomeration to be used.

Predicts Dire Metal Shortage if War Comes

The director of the metals research laboratory at Carnegie Institute of Technology, Pittsburgh, predicts that in the event of war the U. S. will experience shortages in all metals.

Robert F. Mehl said, "We are self-sufficient in only nine basic minerals, and deficient in 23 others. Responsible men have said that though we were but a little short of any metal in the last war, we will be short of every one of them in the next, if there is one."

He added that only through a marriage of research and science can this nation hope to produce the minerals it needs. He called for research in all phases of the minerals industry. Mehl added, "great effort is being expended in developing alloys for use at high temperatures. It has been said that the nation that wins the next war will be the nation that develops this alloy."

He noted that the U. S. is handicapped by a serious shortage of the needed alloy elements.



Artist's conception of the Anaconda plant at Yerrington, Nev. When the open-pit mine goes into operation, crushing and leaching steps will be performed here. Production for the first two years of operation is estimated at 60 million lb of copper. Production is scheduled to begin by the end of 1953.

Greater Butte Block-Caving Project Yields First Ore Shipment to Expanded Anaconda Plant

ENLARGED concentrating facilities at Anaconda, Mont., received first shipments of low grade copper ore from the \$27 million Greater Butte block-caving project. The development is expected to prolong the life of Butte operations and marks the first copper output from Anaconda's postwar improvement program.

It may be that the original tonnage estimates for the Greater Butte project were conservative. Some sources expect 100 million tons above the 150 million ton starting figure, and suggest that this additional tonnage may provide a second low grade operation.

The \$111 million sulfide plant of Chile Exploration Co., at Chuquicamata, Chile, goes into operation soon. This is the most costly part of the

company's \$289 million program. Thirty eight million dollars are earmarked for the open-pit copper mine, leaching-precipitation plant, and townsite at Yerrington, Nev., where production is expected by the end of 1953.

Other metals have not been neglected during the search for increased copper production. Zinc output from the Butte mines, is being increased 50 pct. Uranium ores will be processed and produced for the AEC at a plant being erected at Grants, N. M.

New to Anaconda is aluminum production, for which a plant is planned at Kalispell, Mont. It has been stressed that aluminum is not being considered as a substitute for copper, but that it is another member of this 'family of non-ferrous metals.'

British De-Gassing Coal Seams With Marked Success in North Wales

De-gassing coal seams, called "fire damp drainage," has been practiced for about a decade in United Kingdom. Point of Ayr Colliery, North Wales, has been able to mine a coal seam which would have been otherwise too gassy for mining. In addition, the company saved approximately £40,000 per year in fuel by burning the extracted gas in the mine power plant. Fire damp drain-

age is achieved by drawing the gas through boreholes with induced draft fans.

The boreholes are driven from workings either above or below the seam which is to be drained. Mining has progressed to depths over 1500 ft from the surface of this mine.

The methane content of the gas is approximately 98 pct. The flow of gas diminishes with time but can amount to as much as 400 cfm. The White Haven Colliery, Cumberland, mining under the sea, has also been successful in fire damp drainage by this method.

(Continued on page 645)



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Sudbury Staking Rush Follows Mine Dept. Surveys

Anyone coming off the mark slowly in the staking rush in the 16-township area southwest of Sudbury, Ont., needn't have bothered, with almost every likely site rumored taken up following release of Ontario Department of Mines magnetic and scintillometer surveys.

Company representatives, standing by at Department of Mines offices, used two-way radios and telephones to relay information to men in the field. One outfit is reported to have dropped men into the area by helicopter. Maps released to the public show about six anomalies of outstanding interest. The area is almost on the fringe of the Sudbury Basin. Several nickel showings have been worked in the past, and the supposition is that the anomalies represent norite or other basic rocks favorable for nickel deposition.

It is possible that a worthwhile magnetic concentration is present. Mining interests involved in the rush pointed out that staking was on speculation. Further exploration is required for more definite information.

Anomalies shown by the survey were located near such old nickel mines as the Crean Hill, Chicago, and Sultana, all owned by International Nickel Co. One anomaly appeared in Shakespeare Township, where Falconbridge has done extensive work.

Dominion Gulf Co. men were reported after 50 or 60 claims. The company was one of the most active in the area. Bethlehem Steel also was reported to have staked ground. Falconbridge and interests represented by J. C. Dumbrille were among those acquiring claims.

An Ontario Department of Mines field survey party will be sent to the area soon to investigate results of the twin surveys. The results of the surveys were kept secret until public release of the maps. About 150 maps were sold during the first week, with several smaller groups staking claims.

INCO Labor Dispute Goes To Dept. of Labor

The International Mine, Mill, and Smelter Workers Union applied to the Ontario Department of Labor for conciliation of its dispute with International Nickel Co.

Direct negotiations on contract renewal between union and company broke down, but how far apart they were was not announced. The union, it is understood, asked for a 28½ cent an hour wage increase plus 10 cents or 12 cents in fringe benefits. The union also wants control of mine contracts carrying bonuses. Negotiations involve workers at the Port Colborne refinery and mines and smelters in the Sudbury district.

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Save on installation time and labor. Lorain Liner Plates are made to accurate size and in easily-handled sections . . . can be installed quickly and easily.

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plates and lift bars of U-S-S Lorain Rolled Plate Linings eliminate shell wash and allied troubles which result eventually in costly mill repairs.

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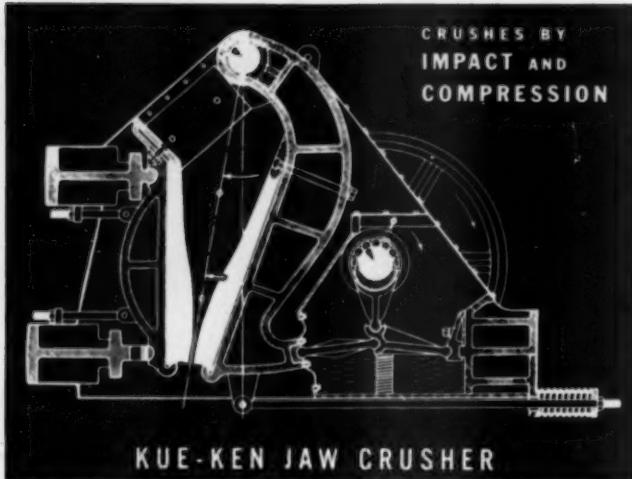
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Expect 10,000 Tons Per Day at Munson Mine

United States Steel's coal mine at Munson, W. Va., is now producing 4000 tons of high-grade metallurgical coal a day, with an expected output of 10,000 tons per day when inside development is completed.

Located 2160 ft above sea level, Mine No. 14 is the sixth major operation by the company's coal division in the district. Other mines are located at Gary, Ream, Filbert, and two at Wilco. All coal from the new operation is sent to U.S. Steel mills in Indiana, Illinois, and Ohio.

Modern mechanical and mining equipment is used throughout, including combination drilling and cutting machines, and high speed loaders. More than 27 miles of track have been laid.

More than a million and one half cubic yds of earth and rock were moved from the mine site in order to make the mine accessible by auto.

Foote to Build Largest Lithium Processing Plant

Foote Mineral Co. will build the world's largest lithium chemical processing plant at Sunbright, Va., as part of a three-way expansion program involving approximately \$3 million.

The company also plans to triple its output of lithium ore at its Kings Mountain mine in North Carolina. In addition, facilities will be constructed for quarrying and processing limestone at Sunbright. Lithium has been placed in Group I, which comprises materials currently insufficient to meet demands, by the Defense Production Administration.

Oliver Mining Options 5400 Acres in Ontario

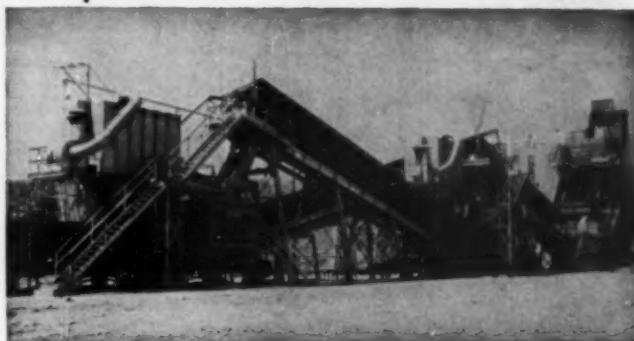
Oliver Iron Mining Co., subsidiary of U.S. Steel Corp., optioned 5400 acres of farm land near Simcoe, Ontario. The land overlies a magnetic anomaly, revealed by Ontario Department of Mines maps, suggesting iron ore at depth.

Two other major steel corporations are actively exploring southern Ontario. Jones & Laughlin Steel Corp. started drilling near Port Hope, 150 miles east of Simcoe in May. Bethlehem Steel Corp. began drilling at Marmora, north of Belleville, earlier in the spring.

The area explored by Oliver lies on the north shore of Lake Erie, and the Jones & Laughlin and Bethlehem developments are on the shore of Lake Ontario. All of these sites offer short rail and lake routes to the mill areas in the U.S.

(Continued on page 651)

Complete plants for crushing ores and non-metallics



Crushing plant at Portland, Colorado, reducing limestone and shale to $\frac{1}{2}$ " size, 300 tons per hour.

● Every function of the completed plant must be engineered with the whole operation in view. Advantage in one department must not create problems elsewhere.

● Stearns-Roger offers COMPLETE service, engineering, design, manufacture, and field construction. Whether you plan an entire new plant or modernizing or enlarging existing structures, you will be well repaid for using the complete facilities of Stearns-Roger.

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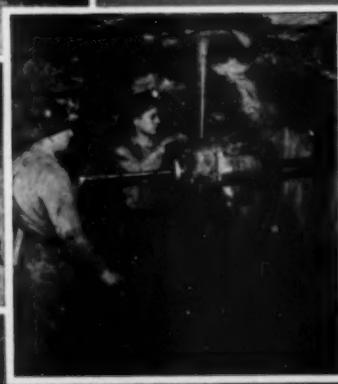


Below: For high-production loading and haulage, Joy teams of truckless loaders and electric or diesel shuttle cars get the call underground.

Right: Complete range of Joy Stoppers includes the new S-91T, with telescopic feed. Requires fewer steel changes, gives more time for drilling.

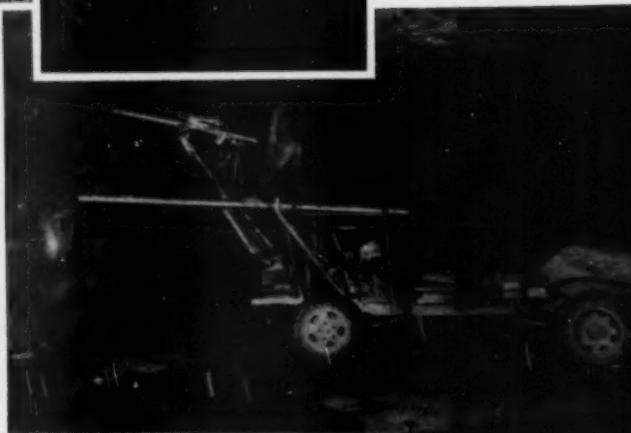
Below: Joy Wagon Drill is a truckless unit designed to drill at any height from toe-holes to horizontal 9' high.

Right: The Joy Drillimobile, a radio-booster, self-propelled, highly maneuverable machine, gives you maximum footage at least once per foot of haul. Features Joy Hydro Drill Jib for fast, accurate hole-positioning, and remote control.



Left: The Joy HS-15 high speed drill for underground blast holes, or core drilling to 500'. Compact and easy handling, with "in-line" vibrationless drive.

Below: Joy Hydro Drill Jibs are versatile units; can be mounted as required to suit individual needs. This truck-mounted Jib is an example.



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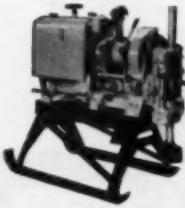
Above: Joy builds a complete line of "Silver Streak" Hand Tools, cadmium-plated for rust protection and easier running in.



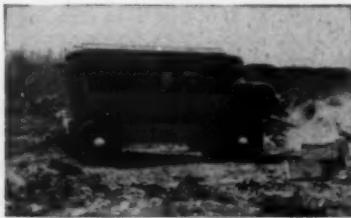
Above: Joy Wagon Drills (Medium and Light-weight models) are easily maneuvered units with positive locking brakes for quick set-ups and balanced drilling on any terrain.



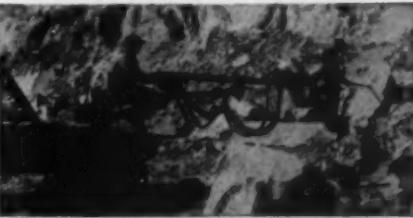
Above: Joy Champion Rotary Drills set absolutely new standards in high-speed, economical blast hole drilling, far outperforming all others. Built in two self-propelled models, for diesel, gasoline engine or electric motor drive.



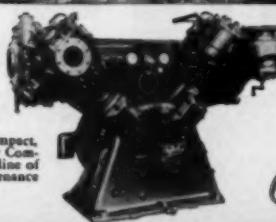
Above: Joy Core Drills range in capacity from 250 to 1750 feet of $1\frac{1}{2}$ " hole. Screw feed or hydraulic types—gasoline, diesel, air or electric drive.



Left above: Joy's popular Series 80 Portable Compressor, with the famous "Econo-Miser" load control, are built in seven sizes, from 60 to 650 CFM.



Above: Joy Hydro Drill Jibs are ready adaptable to truck-mounting, etc., for secondary drilling or top holes in quarries or open-cut mining.



Right Joy pioneered the compact, modern "package-type" Air Compressor—offers a complete line of highly efficient, low maintenance airplants up to 3656 CFM.

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It is frequently used where ore and other material must be moved continuously over long distances . . . has been operated in lengths exceeding 3,000 feet.

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in three belt widths—30, 36 and 42 inches. Range of speeds vary from 175 to 500 feet per minute—capacities up to 18 tons per minute, depending upon speed and size of belt.

While built in standard units for quick, low cost extension of the haulage system, each conveyor is engineered to meet your conditions. For fast, economical transportation—above or below ground—consult a Jeffrey Engineer.

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Complete line of
Material Handling,
Processing and
Mining Equipment

Established 1827

DMPA Bonus Program Set For Columbium-Tantalum

The Defense Materials Procurement Agency announced establishment of a government guaranteed purchase program for columbium-tantalum bearing concentrates needed for defense purposes.

The incentive bonus will approximately double the current market price. Jess Larson, DMPA Administrator, said the purpose of the program is to stimulate development of columbium and tantalum deposits in the United States and abroad. Dealers, as distinguished from producers, do not stand to benefit from the premium prices offered by the government. The bonus amounts to 100 pct of the basic price, and is payable by the Government only to the actual producer of the ore.

The price schedule set forth in the regulation establishes the base price as \$1.40 per pound combined contained pentoxide for ores and concentrates containing a minimum of 35 pct of columbium and tantalum pentoxide. Provision is made for payment for higher grade material. The Fansteel Metallurgical Corp., North Chicago, was designated purchasing agent for the Government.

Combined Metals Expansion Program Nearing Completion

Combined Metals Reduction Co. expects to complete the \$5 million expansion program at its Castleton mine, largest underground mining operation in Nevada, by Aug. 1.

The program will increase production from 700 to 1600 tons per day and raise mill capacity from 1100 tons per day to 1900 tons per day. Iron and manganese will be produced in addition to present lead and zinc concentrates.

Plant expansion includes a new flotation section, third grinding section, and sink-float plant. New equipment, hoist, compressor and pumps will enable the mine to increase its daily tonnage. The Castleton plant, originally built in 1941 to treat sulfide ores, will be able to treat oxidized manganese, lead, silver, zinc, and iron ores.

Pioche Manganese Co., a subsidiary of Combined Metals Reduction Co., will produce ferromanganese from parent company ores in a plant under construction in the old Basic Magnesium factory, Henderson, Nevada. This plant reportedly cost \$3 million and includes two electric furnaces. Pioche Manganese may later occupy Unit 10 of the Basic Magnesium building for a smelter, possibly treating lead and zinc ores.

American Zinc, Freeport Sulphur Scheduled To Send Exploration Teams to Newfoundland

American Zinc, Lead, and Smelting Co., and Freeport Sulphur Co., are scheduled to send exploration teams to Newfoundland to probe mineral deposits, according to the Newfoundland Labrador Corp.

The corporation is a crown company formed to carry out the government's part in economic development of Newfoundland's natural resources. Two groups from American Zinc will explore for base metals in an area

north of the head of Bay d'Espoir on the south coast. The company will make an initial expenditure of \$50,000. Lead already has been reported in the area.

Freeport Sulphur will operate in the Gander Lake and Gander River areas. Encouraging results from an aeromagnetic survey by the government corporation are said to be the motivating reasons for interest shown by the American companies.

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This modern means of mine roof or wall support provides greater safety, economy and better housekeeping...here's why:

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- More clearance is provided overhead and on the sides.
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- Bolts store in less space...handling and transportation costs are reduced.
- Less installation work is required than for timbering.

Investigate the use of CF&I Rock Bolts for your own mining operation. Write for additional information.

CF&I Products for the Mining Industry

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ROCK BOLTS

WHEN the Bolivian revolutionary government clamped a government monopoly over the export and sale of minerals, it served notice to the world that it intends to be pretty tough to deal with in the future. The official Miners' Bank will handle all mineral exports, buying raw materials from producers, and selling to foreign buyers. Another section of the decree gives the Government increased control over the mining industry by providing that Bolivian producers will be paid in native currency at a figure equal to the export price, less handling costs, and a 15 pct commission. The central bank will sell foreign exchange to the mining companies for the purchase of equipment, dividend payments and interest, and other specified purposes.

The order seems to be a prelude to the nationalization of the mines. The Government and trade unions have been studying the move for some time. Nationalization is one of the promises made by the new government when it rode into power. A recent documentary film made by the UN presents the idea that Bolivian mines need mechanization, playing up the crude methods used, and outlines the poverty of the workers. The situation has been overly simplified. It involves much more than poverty. Before the Bolivian miner can be helped, a vast program of education is needed. He cannot be given something he will not accept. Nationalization cannot in itself solve the situation. The Bolivian Government can expect only that it will drive away foreign investors. It has been estimated that some \$40 million would enter Bolivia in 1952. A fair share of the money would have come from the U. S.

INDUSTRIAL accidents last year claimed 16,000 lives, partially disabled 89,000, and temporarily disabled 2 million. The figures emerged during the three-day safety conference convened by President Truman, who called upon the House to enact mine safety legislation without delay. He wants a law which will give the Federal Bureau of Mines the power to enforce Federal standards of coal mine safety. Industry efforts in general to promote safety consciousness are falling far short of ideal effectiveness. The steadily increasing manpower loss, if it continues, may spell out a definite threat to the national defense effort. Labor reserves are only one sixth of what they were in 1939. Under the present dual economy of guns and butter, the U. S. cannot afford the loss in its laboring force, simply because the available replacements are limited. Enough man-hours are being lost because of death and injury to add up to a number of planes, tanks, guns, refrigerators, automobiles, and other things that comprise the dual economy under which the U. S. now lives.

Legislation alone cannot solve the safety problem. The Bureau of Mines reports deaths in metal mines declined during 1951. Coal mine fatalities were up from 0.65 per million man-hr in 1950 to 0.83 in 1951. Almost all safety experts agree that the problem is a personal one. Every miner must be made to under-

stand that his safety is dependent upon active self-interest. Mine operators, viewing the situation objectively, maintain that one of the factors in mine accidents during the early part of 1952 has been the general labor unrest. That Congress can legislate this situation out of existence is open to debate.

The efforts to make the miner understand his role in safe operation have met with some success. Various groups have made steady gains in that direction. The Hero Award Committee, by recognizing extraordinary actions on the part of the men who work the mines, has lent impetus to the idea. Recognition is given to those men who risk their own lives to save others, or take some concrete action which leads to the saving of life.

Another safety promotion program is the Senior of Safety Award, sponsored by the *Explosives Engineer*. As industrial production is stepped up, the danger ratio increases. The last war taught the U. S. a hard lesson—which appears to have been forgotten to some extent. During World War II, industry lost 1,147,208,000 man-days, or enough time to build 52,949 heavy bombers. The nation can ill afford a similar loss again.

COAL mining history might well be called an account of crisis compounding crisis. The industry, throughout its life, has faced a series of problems which had to be met if the industry was to survive. The internal combustion engine and the household oil burner took away markets which were once the sole property of the coal producers. But the industry survived. Higher labor costs threatened to make mining an uneconomical investment, but mechanization, bringing increased production, saved the day.

Today, the use of natural gas threatens to take away additional markets. The steady growth of a web of pipe lines, spreading its tentacles throughout the country, will certainly cut into the amount of coal needed for manufactured gas. Coal must find other means of utilization.

Joseph Pursglove, Jr., vice-president of the Pittsburgh Consolidation Coal Co., at a recent meeting of the American Mining Congress, cited transportation costs as one of the deciding factors in the future of coal. The road seems well outlined. Coal can never hope to compete with natural gas in the area of transportation costs. Right now, the aluminum industry is seeking the cheapest possible power for its reduction and fabricating plants. An answer to the problems of both industries might be to build aluminum plants near coal mines. Electric generating plants could be constructed near the mines, also. The cost of shooting electricity through wires is much less than transporting coal in gondola cars. Another field for investigation is the conversion of solid coal into liquid fuel. Progress in that direction has been made, and in the end may prove to be one of the most important new uses for coal.

Longwall mining, abandoned as a standard practice years ago, is regaining new interest because of

the possibilities of recoveries of up to 90 pct. Engineers are currently studying European equipment. Being used experimentally are the Samson stripper, the Meco-Moore longwall machine, the Lobbe coal plow, and the Dosco longwall machine. The Dominion Steel & Coal Co. reports success with the latter machine in its Nova Scotia installation. The machine offers possibilities of mining coal seams of varying thicknesses down to thin seam coal. Use of the longwall method retreating, may double recoveries. In addition, mining costs can be reduced by less complex handling of mined coal and simpler ventilation circuits.

GOVERNMENT officials, in a joint statement, urged a more aggressive mineral exploration effort within the U. S. Interior Secretary Oscar L. Chapman and Jess Larson, administrator of the Defense Materials Procurement Agency, emphasized the need for the expansion of future reserves, both for civilian and military use. The U. S. is extracting more mineral wealth from the earth than at any other time in its history—but consumption is eating into reserves at a tremendous rate. The future of the U. S. may depend on what is uncovered in the next few years. The nation is approaching the point where depleting natural resources may hurt its position on the world market. In years to come, the advantage the U. S. enjoys may be nullified.



ANDREW FLETCHER, President of St. Joseph Lead Co.

ST. JOSEPH Lead Co., is entering the oil business. Andrew Fletcher, St. Joseph president, stated that plans call for a contract with the Continental Oil Co., to drill 11 exploratory wells. Six will be in Texas, one in southern Louisiana, one in northern Louisiana, and one each in California, Oklahoma, and Montana. St. Joseph is also negotiating a contract with the Zephyr Drilling Co., for wells in Wyoming and Colorado. St. Joseph is planning to drill another well on a 6000 acre plot in southern Illinois. Proxies issued before a special meeting of the board, said the new venture is not intended to change the general character of the company's business, or to involve a significant part of its resources.

If gas, oil, or minerals are discovered in paying quantities, the company will develop and operate the deposits and dispose of the products for the joint account of Continental Oil and St. Joseph Lead. The mining company will contribute a proportionate share of the cost, but will have definite limitation of its obligation.

The amendment to St. Joseph's certificate of corporation, passed by the board meeting, also extended the power of the company to include mining operations of all kinds.

KENNECOTT Copper Corp., has come up with a new application for two-way radio equipment which promises to have far-reaching results. Two-way sets have been in operation at the Santa Rita, N. Mex., open pit. The locomotive whistles and telephones formerly used were found to be impractical during blasting operations. Now, 20 mobile sets, spotted around the pit, are in constant communication with each other and a central, stationary set installed in the control tower. The company reports a definite increase in efficiency and safety.

RUMOR piled on top of rumor in western Ontario, but no one seemed to have anything resembling concrete information. Reportedly, options on certain tobacco lands along the Canadian shore of Lake Erie, near Simcoe, were being granted. The news began to leak out early in May and everyone from Bethlehem Steel to a U. S. tobacco company was named as the taker. And then the story broke.

U. S. Steel's subsidiary, Oliver Mining Co., had taken options on 5400 acres of valuable tobacco land and had scheduled drilling operations. A magnetometer survey released by the Ontario Dept. of Mines re-enforced a report made in 1934 indicating iron ore in the western Ontario region, near Simcoe. Jones & Laughlin has already started to drill at Fort Hope, some 150 miles from Simcoe and Bethlehem also is operating at Marmora, Ont.

Development of western Ontario into an iron ore producing area may be of vital importance to the defense of North America. Planners have long feared that the Sault Ste. Marie locks could be destroyed by enemy bombers in a shooting war, cutting off ore supplies from the Steep Rock region. If ore in mineable quantities is found near Simcoe, a direct rail connection is available to take it to Port Ryerse, a short haul across the lake to Lorain, Cleveland, or Conneaut, Ohio. The ore is said to be at the 3000 ft level. It may take months before the quality of the ore is known, and years before development reaches production stage.

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MINING ENGINEERING

EDITORIAL

FOREIGN MINERALS—OUR SECURITY

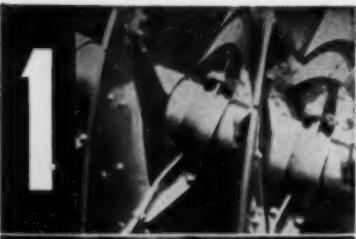
DEPENDENCY on foreign sources for many mineral raw materials is a characteristic of our economy which is becoming painfully evident. Although investment in foreign mining projects has increased, it has not kept up with the growing demand for foreign minerals. The sphere of American investment capital in mining ventures abroad has been severely limited by the rise of nationalism in many underdeveloped countries. Consequently, we can look back over half a century in which mining investment, exclusive of petroleum, has increased by 50 pct whereas other American investments abroad have multiplied by better than 300 pct.

Investment in foreign mining or petroleum encounters different problems than capital investment for other industries. It is rarely invested in industrialized nations. Most of it goes to countries with expanding frontiers, like Canada, or to underdeveloped nations like Liberia. It must be used for building communities, recruiting and training labor, and establishing lines of communication and transportation. These complications are an accepted part of the mining game. However, the most complex problem is in those countries which consider mineral exploitation a usurpation of the people's natural heritage. This is a characteristic of the young government existing by a tenuous balance of power in an underdeveloped nation. American mining capital understandably has

shunned these nations as being poor investment risks. However, they possess minerals which are needed by industry.

Our government has attempted to stimulate mineral supplies beyond those provided from abroad by private capital. ECA, now under DMPA, makes loans to foreign mining companies. Since the ECA program cannot be expected to continue indefinitely, Point IV seems to be the logical next step to encourage foreign countries to fill our shortages. However, only 1 pct of the \$35 million budget provided in the first year for Point IV was allotted for mining programs. Considering the need for minerals and the difficulties of procuring them by private investment, a larger share is needed and justifiable.

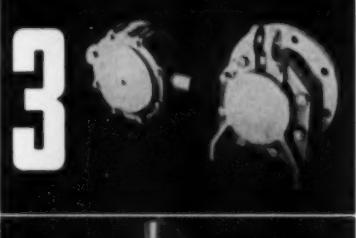
Those who have been engaged in foreign mining can vouch for the fact that it takes many decades to teach the complex technology and economics of mining to the natives of underdeveloped countries. For this reason Point IV must be considered a long range program. Mineral requirements for the present must be met by more direct measures. Encouragement of private investment in foreign mining by such incentives as tax relief on profits from foreign sources, international bank-borrowing facilities for private capital, and diplomatic assistance in encouraging foreign countries to cooperate are imperative for our future mineral security.



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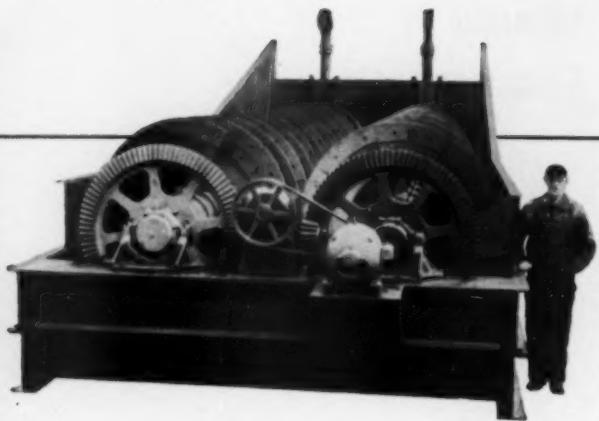
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Before this antiquated Chile mill can be replaced with modern crushing equipment, Latin-American mining laws will have to emerge from the present maze inhibiting foreign investment. The legal tangle serves to retard progress.

A Survey of Latin-American Mining Law

by Edward M. Weiss

THE emphasis in some political quarters on hemispheric unity and defense indicates Latin American mineral resources should be more extensively developed. However, United States mining companies have, in many instances, been discouraged by the laws of southern neighbors. At the same time, some of the countries have liberalized their mining laws in an effort to attract investments from the United States. The resultant confusion has been detrimental to all concerned.

Ownership of Mineral Deposits

Examination of the mining codes of Latin American countries shows that, without exception, governments reserve the right of direct ownership of all mineral resources. Ownership can be divided between the Federal Government and the states or among the Federal Government, the states, and private individuals. However, in the majority of the nations constitutional authority vests all mineral rights solely in the Federal Government.

Mexico is the only country that has expressed

MR. WEISS is with Foreign Minerals Region, U. S. Bureau of Mines, Washington, D. C.

Federal ownership as imprescriptible; the other republics have not defined the exact significance of government ownership. The implication derived from the general economic and political climate is that all mineral resources are ultimately to be regarded as a national heritage.

Whether a concession granted to an individual or corporation carries any right of private property is shaded with a variety of meanings. The exceptions at one extreme are Argentina and Bolivia, whose laws state explicitly that a concession granted to a juridical person is an act of the state, and the land becomes the private property of the individual, and the concessions constitute real property.

However, in Mexico mining concessions or grants do not create rights of fee-simple ownership. The concession only conveys the exclusive right to explore, develop, and work the deposits. The mining property remains the property of the state.

In some instances exploitation concessions represent a compromise between private and government ownership. In Honduras the period granted to a mining enterprise is fixed at 90 years. At the end of that time, the enterprise and all installations revert to the state without compensation.

In many Latin American countries laws governing ownership and disposition of mineral deposits are either nonexistent, as in Ecuador, El Salvador, Honduras, Panama, and Paraguay, or greatly outdated, as in Guatemala and Costa Rica. In the former country a new and more liberal mining law has been presented to the Legislative Assembly by the Ministry of Agriculture and Industries. If an individual or company wishes to exploit a mineral resource in these countries, a contract must be negotiated and the final terms approved by the constituent assembly or congress of the country. This practice is quite common in the Central American republics, where interest in mining has recently been stimulated.

ered government property, regardless of surface ownership, but concession may be granted to exploit these minerals.

In some countries specific minerals may be subject to expropriation by declaring them a public utility. This right is reserved in the mining codes of Argentina, Uruguay, and Venezuela. Under the mining laws of Venezuela, the national executive can exclude from normal channels of exploitation any or all mineral substances found within the republic. Under this authorization, the exploration for beryl has been reserved to the state. Argentina has restricted the export of all strategic minerals.

The concessions granted by Latin American Governments to explore or exploit their mineral re-



High in Peru's Andes, copper ore is carried along by aerial tram. Foreign investment, operating under favorable laws, has been able to modernize mines in countries where resources would have been otherwise unavailable.

Venezuela is the only country in which ownership is vested solely in the states of the republic. The constitution, however, specifies that, although the states are sole owners of mineral deposits, administration of the deposits is a function of the national government. Thus, exploitation concessions can be granted by the states, but only in accordance with national regulations.

In some instances the ownership of mineral resources may be divided among three owners as occurs in Colombia, Cuba, and Haiti. The simplest case is Colombia, where the national government owns all salt and emerald deposits, the states own all gold, silver, platinum, and copper deposits, and the land owner holds all other minerals.

A more complex problem of division of ownership is posed by Haiti and Cuba, where the ownership is based upon a legal classification. In Cuba, legislation has divided all minerals other than coal and oil into three groups. First, nonmetallastics, used primarily for construction; second, slag heaps, iron ore, aluminous earths, and mineral deposits known as placers; third, veins of metalliferous substances.

The minerals included in the first and second groups are reserved for public benefit when located on public lands. If they are located on privately owned lands, they belong to the owner. In the case of the second group, the owner of the land has a preferred right to exploit them. If he does not, the Government may expropriate the land after just compensation. The minerals of the third group are consid-

sources are granted to any individual, regardless of nationality, except in Brazil, Mexico, Uruguay, and the Dominican Republic. The Brazilian Constitution, promulgated on September 18, 1946, provides that authorization to engage in mineral exploration and development may be granted only to Brazilian citizens. However, the Department of Mineral Production, with the consent of the Minister of Agriculture, considers constitutional requirements satisfied if companies are organized in Brazil under Brazilian legislation.

Mexico has a more stringent provision regarding nationality. The sections pertaining to mining in the Mexican Alien Law of 1925 limit the acquisition of mineral concessions by foreigners or by Mexican mining companies with foreign stockholders. The Secretary of Foreign Relations has the power to interpret and enforce the Alien Law. It was decided that the limitation pertaining to the mining and metallurgical industries would not be enforced. However, the Mexican Department of Mines reserves jurisdictional power in particular cases. This ambiguous interpretation is an attempt to reconcile desire for greater industrialization, with the political economic policies of government control.

Government Promotion of Mining Industries

Emphasis in South America has been on development of mining and metallurgical enterprises. However, the size of the projects planned and the reluctance of domestic private capital to take risks make

government financing or government participation in some form unavoidable.

Argentina, Colombia, Bolivia, Brazil, El Salvador, Mexico, Peru, and Venezuela have general government agencies that offer help and advice to mining. The agencies provide technical services, establish research laboratories, and occasionally furnish financial aid. The Trade Development Corporation of Argentina has been the most aggressive of this type of government agency. It has also been active in foreign countries in an attempt to gain interest in Argentine mining ventures.

The quasi-governmental type of organization resulted either from a government's desire to exercise control over the production of a particular mineral, or the government invested large sums in mining enterprises. Chile dominates the nitrate industry through the Chilean Nitrate Iodine Corp.

In other Latin American countries, mining banks have been organized to provide government aid to domestic mining. Banks are found in Bolivia, Brazil, Chile, and Peru. In Brazil the mining branch of the

The countries presenting the greatest difficulty to setting up private mining ventures are Brazil and Mexico. The laws of these two countries are generally regarded by U. S. business men as rigid and difficult to adapt to their undertakings.

Most of the countries exercise controls over transfer of profits abroad, dividends, and dollar salaries of U. S. engineers. However, in those countries where there is active interest in promoting new mining ventures, special measures are provided to assure the return of profits or amortization payments on new foreign capital.

Another consideration is the employment of nationals. All the Latin American countries except Argentina state that a minimum number of nationals must be employed by a mining company. The percentage of personnel that must be made up of nationals may run as high as 85 to 90 pct, as in the case of Bolivia, Ecuador, and Mexico. An additional provision in the laws of Colombia and Costa Rica states 70 to 85 pct of the total wages must be paid to nationals.



Donkeys carry ore along a mountain trail in Honduras. Foreign investment is a strong force in changing mining from a hazardous business into a substantial part of the country's economy.

Bank of Brazil takes the place of a separate mining bank. This mining branch plays an important part in financing the mining industry and its activities provide means by which the government participates in mineral exploitation.

In Bolivia, Chile, and Peru the mining banks have confined themselves to ore buying, exploration, and technical advice. Mining banks have been especially helpful to small operators by buying their ores at premium prices and making mining equipment available at cost. Another advantage to the small operator has been the installation of concentrating and processing plants by the mining banks. Life of the deposits has been thus extended by processing low grade ores.

Regulations Affecting Mining Companies

Latin American governments have increasingly tended toward special contractual agreements when large mining investments are involved. Interpretation of Latin American laws, with regard to the amount and kind of investment, must be made in the light of the range of negotiation possible with the government concerned.

In some countries provisions can be made to rescind the regulations in part, particularly during the initial phases of a new mining venture, when a larger percentage of foreign personnel may be required for technical and skilled positions. These concessions usually call for a training of nationals to eventually fill all positions up to the percentage required by law.

Mining Taxation

The problem of mineral production taxation is perhaps the greatest single factor influencing establishment of new ventures. Many Latin American countries have taxed the established industries with no regard for the unique problems of a mining enterprise.

However, many countries are concentrating on more efficient methods of tax gathering and centralization of tax authority. In addition, some countries recently offered concessions granting a reduction or elimination of the majority of taxes to new mining enterprises. The problem of relieving the tax burden is complicated. The majority of the countries having the greatest amount of taxation are those most dependent on this source of revenue.

The principal taxes found in all Latin American countries are:

1—A canon or license tax, paid annually and levied on the area of the land owned. In Haiti, Uruguay, and Venezuela a canon or tax is also levied on the production of a mining property.

2—A royalty tax paid to the government, usually based on a calculated percent of the value of the gross production of the minerals mined.

3—A profits or income tax, usually levied on income above a certain minimum. In Chile foreign companies are required to pay an additional tax on all income derived in the country. Under the liberal policy of Peru, payment of the canon and income taxes exempts the mining company for 25 years from taxes created or to be created in future.

4—An export tax levied primarily for revenue purposes, limited by federal law to not more than 5 pct *ad valorem*.

5—An import tax. Import duties are usually rescinded on equipment and machinery needed for developing mining enterprises.

Bolivian Taxation

Tax systems of Bolivia and Mexico illustrate the main situations in Latin American countries. Bolivia represents the tendency to regard the mining industries as a catch-all for raising revenue.

In addition to the ordinary taxes on mining enterprises, a complex series of export duties has resulted from additions and alterations of the laws. A shipment of tin made from the Department of Potosi in Bolivia was traced by the U. S. Commerce Department and found subject to the following 15 taxes: Basic export duty, applied on the basis of the market price of tin at the date of export; surcharge on the basic export duty; statistical tax, for the support of the Government Office of Statistics; surcharge on statistical tax; department additional tax; university tax, for the support of all universities; national defense tax; tax for printers' fund; additional tax; Potosi Centennial tax; surcharge on Potosi Centennial tax; Potosi University tax; surcharge on Potosi University tax; tin research tax, and social aid and Oruro and Potosi University tax.

The taxes amounted to more than 25 pct of the value of the shipment.

Mexican Taxation

Mexico, on the other hand, does not depend exclusively upon mineral taxation as a source of revenue, but constitutional policy is that the state must have a fair share of the nation's mineral wealth. Consequently, the Government imposes a relatively high tax upon mineral resources.

Although Mexico's tax laws are formulated in terms of pesos, the peso price is based on world price. Therefore, when the New York price of a mineral goes up or down, the peso price in Mexico fluctuates with it.

The principal taxes levied on mining enterprises in Mexico are:

1—A surface tax, which is levied on the title of a claim, regardless of whether it is being worked.

2—A production tax, which is essentially a severance tax. Most of the governmental revenue obtained from the mineral industry is through this tax.

3—A surtax by which all Federal taxes, including export taxes, are increased by 10 pct of the specified amount. This surtax is allocated to amortization of the federal debt.

4—Other taxes common to all industry, such as income tax, social security, and social benefit taxes.

5—Export taxes, which are at a specified ad valorem rate fixed monthly by the Ministry of Finance.

6—Import taxes, usually suspended on imports of machinery and equipment for mining companies.

7—A special ad valorem export surtax of 15 pct, which was put into effect after the devaluation of the peso at the end of July, 1948. This tax was to capture the exchange profits resulting from the devaluation. Some relief from this tax is afforded by the provision that the increment by which the production tax is raised by the devaluation can be applied as payment to the surtax.

Exemptions and reductions of mining taxes in Mexico can be obtained in special cases. For instance, if a mining property is in an isolated area and has never been worked, the production tax is reduced 50 pct for two years, then gradually increased.

Exchange Control

During the depression of the early thirties, the Latin American countries joined the movement started by various European countries to control foreign exchange. At that time, prices of Latin American raw materials declined more rapidly than the prices of imports. Consequently, supplies of foreign exchange were reduced, and a rationing system became necessary. Exchange control was found to be useful in aiding Latin American efforts toward specific projects. This form of control has been a major feature in recent Latin American foreign trade policies.

In most instances, as pointed out by Horn and Brice in *Latin-American Trade and Economics*, Latin American exchange controls were made to serve specific purposes. These purposes, so far as they affect minerals from Latin America, are:

► Discrimination against certain countries: The Argentine Government uses the exchange-control system to favor certain nations with which it wishes to increase trade for economic or political reasons. Special exchange rates are granted in various trade operations.

► Preferential treatment for necessary imports: In Nicaragua, for example, mining equipment is not admitted duty free, but it is granted a preferential rate in foreign exchange.

► Acquiring revenue: Some Latin American countries acquire considerable revenue from transactions under control systems. In Bolivia all foreign exchange obtained up to a certain minimum price set for minerals must be sold to the Central Bank at the official rate, substantially below the free rate. Although exporters of minerals can deduct certain dollar costs for production charges, these do not include dollar salaries of U. S. engineers or dividends on dollar investments in the mines. When mineral prices rise above the set minimum, exporters are required to sell additional foreign exchange without deductions of any kind.

► Stimulating certain exports: The kinds of commodities exported have been influenced by differentials in the rates at which exporters sell the exchange proceeds of their exports. Because of this, most minerals are in a less-favorable position than other exports.

The only Latin American countries that have not controlled their foreign exchange are Cuba, the Dominican Republic, El Salvador, Guatemala, Haiti, Mexico, Panama, and Venezuela. Most of them have granted authority to their national banks to establish exchange controls whenever necessary.



Point IV —

Medieval Mining Frontiers Pushed Back

by Alan Probert

IN his inaugural address in 1949, President Truman made a policy declaration which launched the foreign technical assistance program known to the world as Point Four. Congress passed Public Law 535 defining the scope of the program and holding activities to certain limitations. It also provided \$34.5 million for the first fiscal year.

The Technical Cooperation Administration was established within the Department of State to coordinate and direct a program to include "economic, engineering, medical, educational, agricultural, fishery, mineral and fiscal surveys, demonstration, training and similar projects." The mineral pro-

grams of Point Four have been staffed and managed by two agencies of the Department of Interior, the Geological Survey and the Bureau of Mines. The Geological Survey is concerned primarily with water-supply problems, the discovery of mineral deposits, and the determination of habit, shape, and grade of mineral deposits. The Bureau of Mines is concerned with determining the commercial potentialities of mineral deposits, mineral technology, and the production and distribution of mineral commodities. Mineral projects comprised only 1 pct of the first year's budget. In spite of the relatively insignificant expenditure compared to those for food, agriculture, and health, a commendable record has been achieved.

MR. PROBERT is Assistant Regional Director, Foreign Minerals Region, U. S. Bureau of Mines, Washington, D. C.



A Brazilian chemical engineer, training under the Point IV program, is acquiring technical skill in oil-shale processing at Bureau of Mines facilities at Laramie, Wyo., and Rifle, Colo. Because it now imports petroleum products at high cost, Brazil plans to develop its oil-shale resources.



A Brazilian chemical engineer works the control panel at the Rifle, Colo., demonstration plant of the Bureau of Mines. He is studying retorting and refining as a Point IV trainee.



Mexican Point IV trainee samples washed coal from heavy-medium pilot plant, Northwest Experiment Station, U. S. Bureau of Mines, Seattle, Wash. He is studying coal technology and may some day help to solve some of Mexico's fuel problems.



Point Four mineral projects are wholly devoted to technical assistance in cooperation with other governments and have no direct responsibility for procurement. The objective of the program is to impart American skills and techniques directly to the peoples of industrially underdeveloped countries. However, a project which results in technological progress in minerals production must add to the supply of mineral raw materials in the markets of the free world.

According to the broad conditions for cooperation that determine the pattern of operations, requests for assistance originate with the government of the foreign country, reaching the United States through the channel of the host government's foreign office and our Diplomatic Mission. The agreements contain conditions clearly indicating the contribution expected from the host government. . . . "Assistance shall be made available only where the President determines that that country being assisted . . . pays a fair share of the cost of the programs . . ." During the first fiscal year it was reported that, for every dollar of United States contribution, approximately \$3 was provided by the cooperating governments. This makes it possible to carry on extensive programs at low cost to the United States.

The Bureau of Mines is conducting programs under a great variety of conditions. The work is directed by the Foreign Minerals Region of the Bureau of Mines, with headquarters in Washington, through the chief of party in each foreign field office. Foreign Mineral staffs range from one to five employees, depending upon the type of technical assistance requested. A country director appointed by the Technical Cooperation Administration is re-

This Brazilian analytical chemist hopes to increase his country's laboratory output when he returns home after a year's training in the U. S. He is assigned to the chemical laboratory of the Bureau of Mines Metallurgical Experiment Station at Salt Lake City, learning American analytical methods.



One of Brazil's few women chemists is learning by experience at the Bureau of Mines oil-shale demonstration plant near Rifle, Colo.

sponsible for over-all coordination and planning for all groups of technicians, including mineral men, working within his area. Experience has demonstrated that successful programs in the mineral field must be provided, with adequate technical support and backstopping by the agency at home. With rare exceptions, it has been found necessary to provide analytical and testing services in the United States in greater or less degree, for all field parties.

Brazil

The most important foreign mineral project conducted by the Bureau of Mines involved metallurgical consultation with the Department of Mineral Production of Brazil. Operated successfully long before Point Four, the program has continued under the new arrangement. The government laboratories at Rio de Janeiro for metallurgical and beneficiation testing and research had been in operation for years. In 1942 a Bureau of Mines metallurgist was assigned to assist in expanding the services of the laboratories under the scientific and cultural cooperation program of the Department of State. Nonmetallics research was emphasized, but other problems dealing with metals also received attention. Important contributions were made to the national steel industry, and valuable practical aid was rendered to a small lead mine in Paraná State where smelting and refining had bogged down technically. A 10-year agreement was signed for continuing the program even before Point Four existed. Cooperative work in coal technology in Brazil has been intermittent over the past decade. Bureau of Mines and Brazilian engineers and technologists worked in harmony in developing the republic's solid fuels industry.

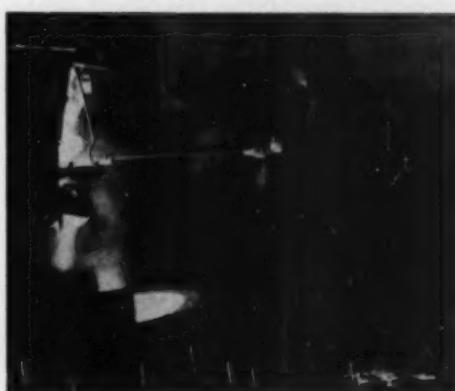
Point IV trainee from Brazil raking refining slag from Riddle ferro-nickel at U. S. Bureau of Mines Electrodevelopment Laboratory, Albany, Oregon. He had steel melt experience in Brazil and served as the metallurgist in charge of refining heats of ferro-nickel at Albany.



A Mexican national presses briquette made from low-rank Mexican coal at Bureau of Mines coal laboratories, Denver Federal Center, Denver, Colo. He is doing research with smokeless fuel that will replace charcoal, commonly used in his country.



This trainee from Mexico (right), may some day advance his country's fluor spar industry. He is at work at the U. S. Bureau of Mines Rolla, Mo., laboratory, where he studies in the gravity section of the ore dressing laboratory under an American engineer.



Afghanistan

On the opposite side of the world, in the high mountains of Afghanistan, the Bureau of Mines takes an active part in the program of the Royal Afghan Ministry of Mines. A drilling campaign supervised by Bureau personnel resulted in publication of full information relative to a fair-size chrome deposit, which has since attracted private capital. The mineral resources of the kingdom of Afghanistan are not large, but important to the economy of the country. Attention has been directed toward improvement of coal-mining methods to insure greater production from the deposits of Ispushtu and Karkar, about 200 miles north of Kabul, the capital. Transportation is poor, and coal-mining methods primitive. No wood of importance is available, and liquid fuels are imported at high cost. Kabul residents depend upon the irregular coal supply for domestic fuel. Currently two Bureau engineers are aiding the Afghans to train men and improve practice to permit economical and practical exploitation of the coal measures. Before mechanization can be considered, it is necessary to teach basic handling of the simplest tools, and to substitute systematic mining for the irregular, dangerous practices traditionally used.

Last summer two explosions and a mine fire occurred in the Afghan mines, fortunately with few fatalities. The fire threatened the entire coal output, and an expert from the Health and Safety Division of the Bureau flew to Kabul. Prompt and efficient action resulted in extinguishing the fires and bringing the mines back into production. The quick response to the urgent call for help proved to the Afghans that the U. S. meant what it said in the Point Four declaration. Afghan coal is the key to future industrialization. Houses have to be built at the mines and machinery substituted for hand labor before even minor development can proceed. The first steps have been taken, and continuation of the present technical assistance program promises future improvement. The Deputy Minister of Mines of Afghanistan is an engineer. He visited the United States last year on a fellowship, and for weeks worked underground in the State of Washington, where coal occurrences are similar to those of Ispushtu and Karkar. He also visited mining areas in many other sections of the U. S.

Nepal

About two years ago, Nepal requested technical aid for its Ministry of Mines in appraising and evaluating the mineral resources of the land, with the expectation that primary exploration would provide incentives for private capital. A Bureau of Mines mining engineer was detailed from Afghanistan to take a quick look at the area, gathering information on which to plan further investigation if warranted. The reconnaissance indicated that a technical aid project would be worthwhile, and steps were taken to return the same engineer to Nepal the following dry season. Nepal is mountainous and largely without roads in the regions where mineral resources are located. The American and a Nepalese engineer, accompanied by bearers to carry supplies and equipment, have been in the field, beyond reach of communications, for the past two months. Placer and vein-gold deposits, zinc and lead ores, cobalt occurrences, and cement rock are being examined.

Afghanistan is bordered by Pakistan, Iran, and the USSR. Nepal is sandwiched between India and

Tibet. In both areas the U. S. is doing an important job of helping people to a better life and to remain free, by giving them technical assistance, thus presenting another block to communism.

India

India applied to the United States for assistance in the study of the lignite deposits of Madras as a source of much-needed power for industry. In the South Arcot district is a large, irregular body of lignite, variable in thickness and attitude, buried under a thick cover of overburden and plagued with artesian water above and below. No economical method of exploitation has been devised, but a board of investigators has been appointed and the studies resumed. The Indian Government asked that the Bureau of Mines make available an experienced engineer who could work with the board and provide contact with the United States that would insure that all developments in mechanization and technology would receive consideration. The Bureau engineer arrived in India last fall. The enthusiasm resulting from this cooperative effort has increased, and an inquiry has already been received asking for further study of lignites in another area of India. A general review of the mineral resources is now being planned by the country director, who foresees the need for coordinating this basic natural resource type of investigation with the general Point Four technical aid program of that country. India greatly increased its shipments of manganese ore to the United States after Russia shut off supplies in 1949.

Mexico

Mexico has yielded great mineral wealth to the world for over four centuries. The Bureau of Mines has had a technical aid program in Mexico for a number of years with technicians working in metallurgical and solid-fuel fields. Numerous organizations of the Mexican Federal Government deal with mineral problems. A little more than two years ago, a National Institute for the Investigation of Mineral Resources was established. Representatives of the 10 agencies compose it as directors. The Institute coordinates the work of Mexican and cooperating United States organizations.

It must be recognized that organization of government differs in many countries from the American pattern. In Mexico, the Commission for Mineral Development is also the custodian of the public domain relative to mineral lands. It owns and operates laboratories and small beneficiation plants and metallurgical operations. There are also cooperative organizations, the outgrowth of past government political activity, which are supervised by Government-appointed engineers to prevent financial disaster. Some few privately owned mines operate under loans from Government banking institutions; but, by and large, mining in Mexico is done by private capital. Requests have been received from the Mexican Foreign Office on behalf of the several agencies requiring the services of United States technicians to work in cooperation with Mexican engineers and technologists.

One project—currently of great importance to Mexico—is development of an economic substitute for charcoal, traditionally the domestic fuel of the country. The Bureau of Mines was asked to participate in the study. Two tungsten mills and a fluor-spar-beneficiation plant, all privately owned, have

also been aided through technical cooperation projects in which Mexican and American engineers participate jointly. The Government's laboratories and technical services are situated at Tecamachalco near Mexico City. The facilities of this plant, which is part of the Commission for Mineral Development, are used in connection with Government-sponsored operations, but are also available to private industry. Recently, emphasis has been given to the desire of the Mexican Government to assist small miners with help in the treatment of ores from isolated areas, where transportation makes beneficiation before shipment a necessary step to exploitation.

Bolivia

The low-grade tin ores of Bolivia have been under investigation by the Bureau of Mines for several years. Fundamental research has been necessary in the light of failure of previous attempts at direct reduction of tin from low-grade ore, tailings, and dump material. All the work is done in domestic laboratories of the Bureau of Mines owing to lack of adequate facilities in Bolivia. Through the cooperation of the large mining companies of Bolivia, it has been possible to arrive at an evaluation of the size and nature of the low-grade tin reserves. A large hemispheric source of tin exists there, but its availability for free world use depends upon solution of problems involved in its recovery.

Colombia

The coal-mining industry of Colombia is growing rapidly as a result of cooperation with the Bureau of Mines. The Commission for Industrial Development is the cooperating agency that works with two Bureau engineers currently in Colombia. Cooperative studies include coal-washing technology, investigation of the type of large-scale installation best-suited to the treatment of Colombian coals, and coal-mining methods. Colombia is remedying its inability to produce a regular and adequate supply of coal to meet the needs of transportation and industry. The steel industry is expanding and it is also expected that coal will soon be exported.

Bureau of Mines Field

Private consultants operate in the same areas where the Bureau of Mines cooperates with Government agencies. There is no overlap in the sense of invasion of the private consulting field by Bureau



A Point IV technical advisor is currently in Nepal, and someday the results of his investigations and recommendations will replace the tools of these Nepalese miners with modern equipment. They are working with pick, hammer, chisel and basket.

engineers. Most of the work done under the technical assistance program requires Government financing or at least preliminary investigation and study at Government expense before private capital will enter the field. Close liaison is maintained with mining-company officials and private consultants. Better understanding between the interests of capital and the Foreign Government agencies has frequently been accomplished through the medium of the Bureau, and every effort to stimulate free enterprise and capital investment is made.

Because facilities for testing and research are generally better in the United States many samples are submitted to Bureau laboratories in this country for microscopic, chemical, or other examination. Steps are being taken to promote installation of laboratories suited to the needs of each country and relieve the Bureau of this work load.

Training Program

Perhaps the most important phase of the Point Four program of the Bureau is that of training foreign nationals. In some countries there are well-trained, competent engineers and technicians. Many of them need advanced study and observation and training along specialized lines.

Two types of training are given to those who come to the United States. These are (1) programs for young, technically trained men and women with limited experience and (2) "Leader" programs for mature engineers and technicians who have good technical background and long experience, and who can profit by visits of observation to mines, mills, smelters and industrial plants in the United States.

All trainees, of whatever type, are screened to insure that their presence here is not a security risk and that they are technically and personally qualified.

Leaders usually come here with definite ideas as to the type of plant they wish to see. Very few "Leader" grants are provided. They are given only to outstanding, well-qualified persons. A short period of orientation by the State Department provides an interval for consultation with the technical agency, and allows time to work out the beginning of a carefully planned itinerary. Industry has given its wholehearted support in granting permission for the leaders sponsored by the Bureau of Mines to visit unrestricted plants and laboratories.

Young, technically trained foreign nationals spend four months to a year in the U. S., on in-service training grants. They are graduates of technical schools and have some experience in industry. On arrival they are given two to four weeks intensive orientation in English, American history and government, geography, and general studies.

After orientation, each trainee is sent to a Bureau of Mines laboratory or experiment station and placed under the direction of a supervisor. The trainee participates in the unclassified work of the station, complies with the hours of work of the Bureau, and takes part in such activities as are suggested by his supervisor. Twenty-odd trainees are currently working in Bureau of Mines laboratories, including two young women technicians. These young people will be dealing with Americans through the years to come in connection with mineral-resource developments in their own countries. The feeling of friendship and good-will that they carry with them will contribute to better understanding in future relations with the United States.

The Broadening Road to Foreign Investment

by Howland Bancroft

AMERICAN investment in foreign mining interests today faces its greatest task. U. S. dollars must make possible the steady procurement of the minerals our defense effort consumes in huge quantities. The two most vital factors involved in foreign procurement are time and the continued good will of the nations from which minerals are purchased. The Point IV program was formulated to care for the second item, but it has failed to do the job. Its lack of success has not been from intent or from basic failure in formula.

Foreign Investment, Four Eras

Foreign mineral development, in so far as participation by private capital from the United States is concerned, may be divided into four main chronological categories:

First: The period prior to the first World War when people, capital and products moved with relative freedom across international boundaries, and London was the recognized mining seat of the world. By the end of 1919 the United States direct investments abroad amounted to \$3.9 billion of which some \$900 million were in mining and smelting and \$600 million in petroleum. Investment climate throughout most of the world was excellent.

Second: The period between the end of World War I, when the international economy had been shaken from its foundations, and the beginning of the great depression of the 1930's, which still further disrupted the world economy. By that time the world mining center had moved across the sea and the United States direct investments abroad had increased to \$7.7 billion of which mining and smelting accounted for \$1.2 billion and petroleum for \$1.1 billion. Investment climate was good in most parts of the world.

Third: The period of the depression of the 1930's and the beginning of World War II during which foreign trade was still further disorganized and the international economy collapsed. Nazi barter agree-

ments were initiated in many parts of the world, and Soviet propaganda commenced to make its influence felt in many countries. During this period United States direct investments abroad decreased to \$7.3 billion. Mining and smelting investments during the same period decreased some \$200 million, though direct investments in foreign petroleum areas increased an equal amount. Investment climate became less and less hospitable in all parts of the world affected by economic nationalism.

Fourth: The period since the beginning of World War II during which total direct investments abroad increased from \$7.3 to \$13.7 billion. Of this sum, at the beginning of 1950 investment in foreign mining and smelting is reported to have been \$1.2 billion—back to where it was in 1929, and in petroleum to have reached \$3.7 billion. Investment climate remained favorable in the countries respecting contractual obligations and fair in their treatment of invested capital.

Recapitulation—Direct Foreign Investments
(in billions of dollars)

Period	Total	Mining and Smelting		(to and including 1919) (to and including 1929) (to and including 1940) " " " " 1949)
		Mining	Smelting	
First	3.9	0.9	0.6	
Second	7.7	1.2	1.1	
Third	7.3	1.0	1.3	
Fourth	12.5	1.2	3.7	
To and including 1951 estimated	13.7	1.5+	4.4+	

As noted above, the relative freedom of passage across international boundaries by people, capital and products ended with World War I and the situation remains unchanged in a greater part of the world. While this same war upset international economy, the depression of the 1930's caused the collapse of world trade, and exports from all countries fell to an alarmingly low figure. Some countries almost ceased to export. Chile, for example, reported a drop of 88 pct in exports. Countries with

MR. BANCROFT is a consulting mining engineer in New York City. He is an AIME member.

The United States, with 6 pct of the population and 6.3 pct of the land area, produces half of the total industrial output and a third of the mineral output of the world. Although a "have" nation, the U. S. must import major quantities of ten basic minerals. To insure a continued flow of these minerals which comprise 25 to 100 pct of the national requirements, American capital must go abroad.

but one or two exportable raw materials or products suffer unbelievably from such economic upheavals. With a nearly complete falling off in demand for their exportable raw materials and slackening in foreign investments such areas are ripe for the spread of the Communist doctrine. One result of this collapse of the international economy was the attempt on the part of the governments of many nations to pass the burden of the depression along to other states. They tried to stage their own recovery at the expense of other nations by restricting imports, devaluing currency, invoking exchange controls, dumping surpluses and trying in any number of other ways to lift themselves by their bootstraps, economically. Economic nationalism dominated the world. With decreasing production and increasing population, the lot of the average laborer became steadily worse.

Ten Basic Materials Imported

An endeavor has been made to keep from becoming statistical. Yet, there are some figures which should be borne constantly in mind in determining the need to continue development of foreign mineral resources. With 6 pct of the population of the world and about 6.3 pct of its land area, the United States produces roughly half of the industrial output of the entire world, and mines about one third of the world's mineral output. Yet, its heavy industry depends on imports for a large part of ten basic materials; natural rubber 100 pct, tin 100 pct, nickel 99 pct, chrome 83 pct, manganese 77 pct, bauxite 70 pct, tungsten 50 to 67 pct, zinc 37 pct, lead 33 pct, copper 23 pct.

Notwithstanding the fact that there are grave and serious obstacles to direct foreign investments by private capital—some 21 listed in a report prepared by the National Industrial Conference Board, Inc.—direct foreign investment has increased in the past 12 years according to figures and estimates supplied by the Bureau of Foreign and Domestic Commerce of the United States. Of this \$6.4 billion increase, the petroleum industry accounts for \$3.5 billion, while the mining and smelting industry accounts for but \$300 to \$350 million. Manufacturing, distribution

and miscellaneous investments account for the balance.

Of the total direct investments of the United States mining and smelting industry abroad, but little is invested in the production of such basic materials as manganese, chrome, nickel and tin, for which United States industry is almost wholly dependent on foreign sources. Nor does it include any substantial proportion invested in the production of the so-called strategic and critical materials the U. S. Government is supposed to be stockpiling and which are not domestically available.

Where do the materials in short supply come from? In the main, some 75 pct more or less, come from underdeveloped countries, where living conditions for the vast majority of the people—the labor force—are so bad as to be fruitful grounds for the spread of the Communist doctrine. People with empty stomachs are the most easily influenced by Soviet propaganda. It would appear that a properly administered and implemented Point IV Program might be of inestimable value in checking and possibly halting the spread of Communism and thus afford United States industry a continuing opportunity to obtain raw materials which are absolutely necessary to keep it going. While there is much conjecture about the value of the Point IV Program as presently administered, there can be no conjecture about the origin of the imports required to keep industry alive and to supply strategic and critical material requirements.

The Point IV Program has been stigmatized by referring to it in terms of the "Give-away" or "Hand-out" program and by many other rather uncomplimentary phrases not intended to enhance its acceptability to the American tax payer. However, the possibilities of a properly functioning Point IV Program warrant serious consideration. If the program is found unworkable it would seem imperative that a better plan be suggested to take its place if U. S. industry is to continue to obtain raw materials.

An adequate labor supply requires recruiting. Proper health conditions for labor means building labor camps or compounds where sanitary conditions

may be supervised. Labor communities from a few thousand to several hundred thousand are gradually built up. The United States Government could help by doing on a big scale, insofar as labor and facilities are concerned, what operators have been compelled to do in a small way.

In the past, as now, materials are acquired where the most can be obtained for the least. Price variations and the law of supply and demand continue to function where governments permit them to do so. The demand appears to be firmly established, but the area of supply is most definitely shrinking and is continually menaced by encroachment of Communist control. China is the latest of a long series of economic losses to the West. Others on the list have fallen in a manner so similar that one is led to wonder where and when the hammer will strike next, and how much the sickle will next cleave from our remaining area of supply for critical materials.

The huge royalties paid by private companies to foreign governments and officials do not guarantee the security of the venture. These vast sums, in a number of instances representing hundreds of millions of dollars and at least 50 pct of the profits of the operation, do little to aid the people of the country. Hence, the Communists and the political *outs* have a ready made slogan. "The resources belong to us—down with foreign exploitation of our resources". The slogan is even promoted by the very recipients of these vast payments when the need arises to divert popular wrath from themselves.

The future of United States investment abroad is fraught with all the risks of the past and the new ones arising from economic nationalism. However, the greatest risk of all is not to direct investment, but to the U. S. itself if Communism should continue to march. Our safety lies in keeping the world free by helping the common people obtain enough to eat, promoting sufficient education so they may know something other than conditions of serfdom, and helping provide decent standards of living according to the ideas of the country in which they live. It's building from the bottom up—a long term project.

A Modern Approach

How is this to be accomplished? It is going to require a more modern approach than most would have considered necessary or desirable up to World War II. It seems inevitable now, that to hold these areas of the free world, the self-interest of the peoples involved must be of primary consideration, or there will be no dividends at home.

In considering methods of approach to the problem of assuring our prosperity by promoting world prosperity, Paul Hoffman, in a recent article entitled "World Investment—Not—Foreign Aid," puts the value of the foreign economic program on a mathematical basis. Hoffman says there is general agreement between economists that the budget should not exceed \$40 billion for a sound peace-time economy. He recognizes that until world conditions improve, until the threat of Communist aggression is removed, the U. S. cannot think in terms of this sound budget. However, in Hoffman's opinion, to achieve the conditions which will permit reducing the budget from \$85 billion to \$40 billion, the U. S. Government must spend \$2.5 billion annually in foreign aid. He believes by spending 1 pct of our annual income on "world investment", we shall be eventually able to set our sights on savings of \$40 billion annually. The idea is worth considering. Its focal point is the implementation of Point IV.

About one-half the population of the world lives in so-called underdeveloped countries presently outside of the international Communist area. Their annual per capita income ranges from \$30 to \$152—the average under \$80 per annum—compared with \$1453 per capita in the U. S. Thus, it would appear that over a third of the world population does not produce enough to provide an annual income equal to 6 pct of the \$1453 enjoyed by the people of the United States. Furthermore, in the underdeveloped parts of the world, the population is rising more rapidly than production. This is ideal soil for the germination of Soviet ideas. In passing, it is to be noted that some 750 million people, or about one third of the population of the entire world, now live under Soviet control.

Consideration of the program which may make a modern approach to foreign mineral development possible involves implementation of Point IV, and its administration in such a manner as to accomplish its objective. In very simple terms it means assuring U. S. prosperity, if not salvation, by promoting world prosperity. This subject has been investigated and described by the International Development Advisory Board, under the Chairmanship of Nelson A. Rockefeller, in its report—*Partners in Progress*. It is an earnest plea for the "effective cooperation of all free peoples" and endeavors to show that "joining defense and economic and social development is a fundamental requirement for mankind's progress toward peace, freedom, and well being". The comprehensive manner in which the problem has been investigated and the clear and illustrative way in which data is presented make the report an outstanding contribution. Anyone interested in foreign investments should make the study of this report an imperative. Briefly, the report recommends "national development plans which would strive for simultaneous progress in each of three fields of economic endeavor:

- The production and distribution of goods,—primarily a function of private enterprise.
- Public works,—transportation, roads, irrigation etc. primarily a responsibility of the governments.
- Basic social services,—health, education, citizenship etc. primarily the responsibility of governments.

To expand the outflow of private foreign investment the Board recommends:

- A tax incentive.
- Bilateral tax and commercial treaties.
- Underwriting the transfer risk on foreign dollar obligations.
- A new affiliate of the International Bank to serve private enterprise.
- An assistant administrator in the Overseas Economic Administration charged with no other duties than to encourage the maximum and most effective use of private enterprise.

With the Point IV Program implemented as suggested above, and its effective functioning a recognized part of the foreign policy of the United States, private capital may eventually feel secure in greatly expanding its foreign mining and smelting investments. Meanwhile, it would appear that such expansion as takes place will be confined to countries respecting contractual obligations and who are fair in treatment of invested capital, whether these countries be without or within underdeveloped areas.

Obstacles To U. S. Foreign Investments

The National Industrial Conference Lists them:

- 1—Export and import quotas.
- 2—Limitations on remittance of profits and of other income and expenses payable in dollars.
- 3—Control of capital movements.
- 4—Burden of social security legislation.
- 5—Lack of trained native personnel.
- 6—Lack of adequate roads, railroads, and harbors.
- 7—Multiple exchange rates.
- 8—Inadequacy of housing, recreational and shopping facilities for employees.
- 9—Inadequate power facilities.
- 10—Restriction on imports of personnel from the United States.

Foreign Minerals and American Capital

by H. Dewitt Smith

THE disastrous effect of two major wars on foreign economic health is giving American capital opportunities which might have not otherwise developed. At a time when discovery of major orebodies in the United States awaits fuller application of new geophysical tools and technical methods, U. S. investors must seek other fields where investment may be put to work. The unsettling effects of war have made it almost impossible for foreign nationals to develop mineral wealth, permitting Americans to enter at a time when U. S. mining, with a few exceptions, is in the process of expanding known orebodies and developing only a few new ones.

Available capital, however, is not the only pre-

MR. SMITH is vice-president of the Newmont Mining Corp. He is on AIME member.



requisite for entering the foreign mineral development field. The capital must be able to work in favorable economic atmosphere, a condition not easily satisfied in a world constantly in a state of political and social flux. In many countries, the political theory changes as often as the wind direction in March. Thus, the political stability of the form of government is of prime importance to the investor. In addition, a balanced budget and a moderate tax structure are important. Because in making foreign investment it is inevitable that one will have dealings with government officials, it is basic that they must be of high integrity. In countries fulfilling the requirements, it will usually be found that the economic initiative of the individual is respected.

Newmont Mining Corp.'s three major investments in the last 15 years have been in Canada and the

Union of South Africa. Meanwhile the corporation has continued exploration in other parts of the world, on the premise that possibility of greater profit may offset the hazards of a less politically favorable situation. Many countries which fill the requirements now, may develop a tax structure which will act as a block to development of any but the most promising prospects.

Foreign investment brings with it the responsibility for American capital to behave as a good citizen of the country in which it operates. The welfare of the country, community and employees must be a primary consideration. It involves the sane solution of rate of production without over-consideration of present value tables. Re-invested profits, bringing expanded ore reserves, modern equipment, and labor-saving devices may return greater value over the long run than immediate dividend checks. Careful consideration must be given to installation of smelting and refining plants, and even fabrication units within the country. The company operating in the foreign field today, will often have to provide housing, railroads, and highways in remote areas. Construction of public utilities may be among the facilities the company has to provide.

Taxation, under the modern system, often means a company automatically takes a partner—the nation in which the investment is made. Often, U. S. organizations must accept a minority position in the enterprise. The trick is to make certain that the partner is a good one. Newmont has a 32 pct interest in operations conducted by Société Nord Africaine du Plomb, in Algeria. It has been a proven advantage to Newmont to have French partners carrying out relations with the Algerian and French governments. Several of the obstacles apply only to small companies who are unable to supply their own facilities. Others will hamper groups which neither produce strategic metals or generate foreign exchange for the country in which they operate.

Yet, the United States itself presents the major handicap. The U. S. allows no tax credit on foreign dividends, which have already been bitten into by the country in which they were earned, unless more than 50 pct of the voting stock of the foreign corporation is owned by the taxpayer. An amendment to the internal revenue code allowing partial credit on foreign income taxes to those holding 10 pct or more of the voting stock of a foreign corp., is a step in the right direction.

In the case of the Sherritt-Gordon Mines, Ltd., in which Newmont is committed to an \$8.2 million investment, the principles of a good mine, under excellent management, in a favorable atmosphere are followed almost to the point of reaching the ideal. The good will of the government is best portrayed by its willingness to build 147 miles of railroad from Sheridan to Lynn Lake without guarantees.

O'okiep Copper Co., Ltd.

South African Copper Co., controlled by the same American interests as O'okiep Copper Co., purchased the bankrupt Cape Copper Co., Ltd. interest in the Namaqualand mine for about \$2.66 million, paid between 1925 and 1937. The sum also included the cost of exploration and development of low-grade orebodies. O'okiep, in turn, purchased the assets in 1937, spending \$6.05 million, including expenditures for bringing mine, mill, and smelter into 13,000 ton annual production rate by 1940. About \$12.53 million has been spent on the property to the middle of 1951, raising production to 25,000 tons of blister copper annually.

The Union of South Africa Parliament, recognizing the advantages of this development to poverty-ridden Namaqualand, passed an act in 1937 relieving O'okiep from payment of income taxes until its entire capital expenditure had been recovered from working profits. The procedure has been adopted for all new gold mines.

The Union made provision for dollar exchange to repay approximately \$3.12 million in O'okiep promissory notes to American holders during World War II. An exemption was also made from excess profits taxes during the war, based on because the company had not yet recovered its capital expenditures. Dollars were always available for equipment purchases and payment of dividends to U. S. and Canadian stockholders. A \$1 million dollar 125-mile road was constructed by the Government from the railroad terminus at Bitterfontein to the mines. Government officials were always accessible for handling of export and import permits, exchange, and water and transportation problems.

Metals Reserve Co. advanced \$1.4 million in 1943, repayable in copper, for the only U. S. aid given to the operation.

Tsumeb Corp., Ltd.

The Otavi Minen und Eisenbahn Gesellschaft in South West Africa was purchased from the Custo-



Careful planning, combined with proper execution has made foreign investments worthwhile to Newmont and the nation involved. The Nababeep smelter and mill of the O'okiep Copper Co., Ltd. is the product of cooperation and consideration of all concerned.



The Zellidja operation at Bou Beker surrounds the village and mosque of the employees who operate the installation. In the background can be seen the tailing pond. The machine shop is in the foreground.

dian of Enemy Property in 1947 by Tsumeb Corp., for \$4.04 million. Newmont owns directly 28.5 pct of the company and another 5.35 pct through O'okiep, owners of 9.5 pct. Tsumeb spent \$7.73 million in developing the plant to a capacity of 50,000 tons of lead, copper, zinc, with substantial amounts of cadmium and silver. An additional \$5.25 million will be spent by June, 1953 to raise production to 85,000 tons.

In 1948, the South West Africa Legislative Assembly granted freedom from taxes to all mines until capital expenditures had been recovered from operating profits. Tsumeb was allowed to write off its previous capital expenditures, similar to the grants in accelerated amortization offered new strategic metal properties in the U. S. Tsumeb is now the second city in South West Africa, boasting an excellent school system, a hospital and recreational activities.

Neither Tsumeb nor O'okiep met with any serious political obstacle as outlined by the National Industrial Conference Board. Tsumeb is installing rapid mechanical loading facilities at Walvis Bay. It has also purchased fifty 20-ton cars for Government railway use. The mine has joined the Government in a housing project for area residents who are not employed by the mine and has agreed to lend the local Divisional Council £55,000 at 1 pct for road construction.

Societe Nord-Africaine du Plomb

Société Nord-Africaine du Plomb is an excellent example of how American and French capital can work together. Newmont and St. Joseph Lead Co. technicians have aided the project. Help has also been extended by the Economic Cooperation Administration in the French Morocco and Algeria project. The company was formed in 1946 to prospect a large area contiguous to the mines of Société des Mines de Zellidja. Zellidja owns 51 pct of the stock of N.A.P., while Newmont and St. Joseph hold the balance.

ECA loaned \$500,000 at 4 pct against future production and is committed to another \$1 million for mine and mill equipment. The owners spent \$500,000 and will spend at least an additional \$1 million to bring production to 1000 tons of ore a day.

Zellidja is a Moroccan company in which Newmont and St. Joseph Lead hold 2.65 pct and 1.43 pct interests, respectively. A \$3.6 million dollar ECA loan was obtained through Newmont in Paris for expansion of mill output from 13,595 tons of lead concentrate in 1948, to 85,000 tons of lead concentrate and 120,000 tons of zinc concentrate in 1954. The loan is being repaid in lead and zinc. Ore reserves in 1948 indicated that ECA ran no risk.

Again Newmont and St. Joe aided in the development. Mine and mill costs compare well with any in the Western Hemisphere. As of January 1, 1952, the program was running ahead of schedule.

Newfoundland

Explores its Mineral Wealth

by George G. Thomas

IN April 1949, Newfoundland became the tenth province of Canada. It had been a Dominion of the British Commonwealth, though actual Dominion status had been suspended for some fifteen years. During that fifteen-year period the Government had been by commission.

Throughout the regime of the Commission Government, a limited program of investigation of the mineral resources of the country was in progress. It was during this period that the investigation of the iron resources of Labrador by the predecessors of the Iron Ore Company of Canada began.

Since Confederation there has been a marked change in the attitude of mining capital to the new province and a notable acceleration in the tempo of prospecting and exploration.

There is no private Newfoundland capital available for mineral exploration. In the past, as now, capital must be attracted to the province. Prior to Confederation, Canadian capital had to cross the barriers of customs and immigration. American capital hazily regarded Newfoundland as part of Canada, with one notable exception, the American Smelting and Refining Company at Buchans.

Buchans

The most significant mining development in Newfoundland today is the property of the Buchans Mining Co. Ltd., a subsidiary of the American Smelting and Refining Co., located at the town of Buchans. Their milling operation produces lead, zinc, and copper concentrates by selective flotation, and also

produces a small amount of gravity concentrate. Presently the mill treats about 320,000 tons of ore per year. Production started in 1928 at 500 tons per day and has been raised over the years to the present figure of 1200 tons per day.

Conventional prospecting methods uncovered the original deposit. It was first examined as a possible source of sulphur from pyrite. Geophysical prospecting and diamond drilling resulted in discovery of enough additional ore to warrant a large scale operation.

Mining is by open cut methods. In addition conventional underground cut and fill stoping and square set stoping methods are employed. Between 850 and 900 men are employed at Buchans. Concentrates are shipped by rail to Botwood and leave the country through the port.

Buchans Mining is currently investigating a Crown concession covering an area of approximately 6250 square miles, adjacent to the area of present operations. Aerial photographs have been made of the area, and geologic parties, supplied by plane, are in the field during the summer months. The concession lies south of the Falconbridge concession.

The geology of the Buchans area can be divided into three groups. The first category is the oldest and called the Buchans Series. It consists of volcanic lavas, breccias and tuffs and underlies most of the Red Indian Lake Basin. The second is a group of igneous rocks such as granite and quartz porphyry intrusive in the volcanics. It makes for rough country north and west of Buchans. The third group consists of sills and dykes penetrating the lavas near

MR. THOMAS is a consulting engineer in St. John's, Newfoundland.

the mines. The ore minerals were introduced after the intrusion of the igneous rocks, and they occur chiefly as large sulphide replacements in the tufts.

Falconbridge Concession

One of the first considerations of the Provincial Government after its election was the moribund state of the mineral industry. Complicating matters, the personnel and unpublished information of the existing Geological Survey has been transferred to Ottawa and incorporated in the Geological Survey of Canada. Steps were taken immediately to enlarge the remaining facilities provided to exploration interests by increasing the number of Government-owned diamond drills. Negotiations began with Falconbridge Nickel Mines, Ltd. They were the first group prepared to make definite commitments as to policies and explorations concerning an area some 2500 square miles in northern Newfoundland. As a result of their first season's prospecting on the Concession, now held from the Provincial Government, in an area approximately four thousand ft by two thousand ft, Falconbridge discovered five separate occurrences; two of copper-zinc, one of lead-zinc and two of copper-gold. Diamond drilling is currently going on.

Airborne Magnetometer and Geological Surveys

In 1950 an airborne magnetometer survey was made on an area of 5000 sq miles, complemented by a compilation and interpretation of the bedrock geology. Limited investigations of some of the results obtained in the 1950 survey were undertaken. In addition, reconnaissance geological mapping of an area 6000 square miles was completed utilizing the latest methods and techniques of aerial photography and transportation. As a winter field program, the Provincial Government is now making a ground investigation survey of an area of basic and ultrabasic rocks in Central Newfoundland. This particular basic intrusive was discovered in 1951 during the course of the reconnaissance geological mapping program referred to above. Preliminary traverses indicated the presence of cross fibre asbestos. The present project may secure information which will result in an intensive exploration program in 1952. Late in 1951 additional airborne magnetometer surveys were undertaken on two areas in the western part of the island covering some 500 square miles. Additional information was sought on potential asbestos, chromite and magnetite bearing areas.

Fluorspar, Asbestos, Petroleum

Newfoundland is a substantial producer of fluorspar and one of the most important U. S. sources of supply. Demand is increasing tremendously and to meet it the Provincial Government loaned substantial sums to one of the operating companies primarily to ensure continuity of supply to the U. S.

Similar advances have been made in the development of an asbestos industry.

A year ago the Provincial Government concluded a petroleum exploration agreement with a Boston financial group. A drilling rig has already moved in on one of the more favorable areas. The agreement has two years to run, at the end of which time the firm may select limited areas for development. The Government retains half of any potential field for subsequent development or disposal.

Cement Mill and Gypsum Wall-Board Plant

The Provincial Government has undertaken the development of a cement mill and a gypsum wall-board and plaster lath plant. Previously, an annual consumption of some 200,000 tons of cement was supplied by production from Quebec, Ontario, and imports from Europe. The mill's annual capacity of 100,000 tons will help meet the chronic shortage.

The gypsum wall-board plant, now about to be brought into production, will have a 250,000 square ft capacity per day.

The Crown Corporation

It is perhaps in the formation of the Newfoundland and Labrador Corporation Ltd. or the Crown Corporation as it is popularly called, that the Provincial Government has taken its most unusual action. Under present Dominion, or Federal, income tax laws a province may incorporate and operate a "Crown Corporation" provided not less than 90 pct of the outstanding stock is held by the Provincial Government. The 10 pct of the outstanding stock of the Newfoundland Labrador Corp. is held by two investment houses. Both are among the largest and most influential in the U. S. and Canada.

The Corporation has been in existence for only a few months and there has been insufficient time to plan a detailed investigation policy for mineral resources of the areas reserved to it. The Corporation is interesting certain U. S. and Canadian Mining Companies in a long term investigation and exploration of sections of the areas. Also, it is planning its own long term exploration policy on other sections.

Labrador

The story of the Iron Ore Company of Canada and its tremendous iron ore reserves in Labrador and New Quebec is a familiar one. The geology of the Labrador trough, where the iron ores occur, is remarkably similar, stratigraphically, to some of the Michigan ranges (e.g. the Marquette). In 1951 Frobisher Ltd., working on a Concession area granted by the Newfoundland Government, discovered native copper along a zone at least 16 miles in length. The discoveries were made so late in the season little could be done beyond noting their occurrence, and taking out samples up to 60 lb in weight. 1952 will see an extensive exploration program in this area.

Wabana

The Wabana iron ore deposits are one of the most important mining operations in Newfoundland. Since mining started, more than 40 million tons of ore have been extracted from the property, located on Bell Island in Conception Bay. The workable beds are on the northwest side of the island and mining has been extended into submarine operations under Conception Bay.

The island is of Ordovician sandstone and shale overlaying Cambrian formations. The beds dip northwest and continue under the floor of Conception Bay. Submarine operation under the bay has been carried forward for more than 2 1/4 miles. Reserves have been estimated from 2500 million to 10,000 million tons. In reality, any estimate must take into account the limitations imposed by submarine mining.

Efforts of the Provincial Government have been the primary reason for the beginning made in developing Newfoundland's mineral wealth. It may be expected that results will prove the expenditure of time, effort, and money, has been worthwhile.

Liberia—

The Bomi Hills Development



Mining operations at the Bomi Hills open pit, with the 600 ft cliff towering over the operation. Diamond drilling is in progress, but no immediate plans have been made for going underground. (Photo by Griss Davis, for Black Star)

LIBERIAN ore has been called the richest iron ore mined in the world, and thus far, the output from the Liberian Mining Co.'s Bomi Hills mine has lived up to its reputation. Iron content has been variously given as 68.47 pct to 68.825 pct. A recent United Nations survey gave it first place, surplanting the previously top-rated Swedish product. The first shipment of Liberian ore to the United States reached Baltimore in June, 1952 and went into blast furnaces at Republic Steel's Cleveland plant, where excellent results were reported.

The physical make-up of the ore was hard, dense lumps, free of fines and with ideal size distribution. The Bomi hills mines were scheduled to be in full operation by the end of 1952. At the close of 1951, 200,000 tons of ore had been delivered to Baltimore. Liberian Mining Co. states that production is about 90,000 tons of ore per month at present. Between 1200 and 1500 men are employed at the mine site, with about 25 pct of them Americans.

The Bomi Hill project was financed with the aid of the Export Import bank, which loaned Liberia

Mining part of the sum needed to initiate and put the development into production. No definite expansion plans are in the making but extensive diamond drilling is being pursued. Original estimates of annual production for Bomi Hills ran in the neighborhood of 1.5 million tons, but the figure is no longer applicable.

Liberia's potential as an iron producing country has been known for a long time, but the physical obstacles in the way of large scale production were such as to prohibit even contemplation of the project. Until recent years, the only route from the mine site to Monrovia was a foot trail. Once to the coast, over swamps and unbridged rivers, the ore was still useless because of the lack of loading facilities.

Transportation Solved

One problem was solved with the completion of the artificial harbor at Monrovia. Harbor construction was well under way when the mine project began in 1948. The island location of Monrovia also made the building of a bridge across the St. Paul River necessary. The 980 ft reinforced concrete structure, accommodating railroad and vehicular traffic, was opened in 1949.

Meanwhile, preliminary work on railroad construction started. Grading was completed quickly. In April, 1951, the first train made the trip from Monrovia to the Bomi Hills. About half of the cost of the entire project went into railroad construction. More than 2200 men, often forced to resort to primitive methods, were engaged in clearing a path through the heavy forests between the mine and port. Swamps were drained and filled, and bridges, including the William V. S. Tubman, named for the Liberian President, were constructed.

At the port, a Robbins Conveyor Belt Co., ore-handling plant was installed. Ships can be loaded from the stockpile at the rate of 3000 tons per hr and vessels need spend only one day in port.

Liberian Mining is operating under an 80 year lease, giving the company exclusive mining rights to all minerals, except gold, platinum, and diamonds, within a 40 mile radius of Bomi Hills. The contract provides a fixed royalty to the Liberian Government of five cents per ton of ore extracted, and a premium based on the New York market price for Bessemer-grade pig iron.

The entire project started because an American,

Landsdell K. Christie, served with the U. S. Army in Liberia during World War II and saw the tremendous possibilities dormant in Bomi Hills. He worked out the agreement with President Tubman and formed Liberia Mining Co., Ltd.

According to R. Earle Anderson, in his book *Liberia, America's African Friend*, published by the University of North Carolina Press this year, the mine project alone has cost \$4 million.

Geology and Mining

The iron ore deposits of the Bomi Hills are highly metamorphosed. The actual ore mined consists of magnetite and hematite associated with itabirite, a low grade iron formation (ferroogenous sands). Structural geology of the deposit is simple. It is made up of a thick layer of itabirite above a layer

of clay. The massive high grade ore is beneath the clay.

The high grade ore lenses are in a bowl formation. The bowl is filled with itabirite. The ore is exposed as a cliff jutting some 600 ft into the air. A tunnel blasted into the ore face cuts through one of the sides of the bowl for nearly 500 ft, coming out on the inner slope of the bowl. The adit reveals a cross section through the ore, clay, and itabirite.

At this time, Bomi Hills is an open-pit operation, with underground mining contemplated some time in the future. Iron ore deposits have been discovered in other parts of the country. Thus far, exploration has indicated that the ore quality of the new discoveries is not as high as Bomi Hills.

Republic Steel Co. is taking most of the production from the mine, with anything Republic does not purchase over the contracted amount available to the open market.

Lead Mining Outlook in North Africa

by Rene J. Mechlin

ONE of the bright spots in the mining world since the war has been North Africa, particularly the eastern section of Morocco. The Societe des Mines de Zellidja at Bou Beker, which prior to the war was just coming into production, has, in the past two years, greatly expanded its operations. Starting in 1946 with assistance from the Newmont Mining Corp. and the St. Joseph Lead Co., Zellidja has expanded its mining and milling operations from 8000 tons to a present rate of approximately 100,000 tons per month. Current production from this property is now about 3250 metric tons of pig lead and 1800 tons of zinc per month. Zellidja's neighbor, the Touisset mine of the Royale Asturienne, which in 1945 was treating less than 400 tons per day, has increased its milling facilities to something over 1000 tons per day. Zellidja's other neighbor, Societe Nord Africaine de Plomb, expects to be in production by fall, at a rate approaching 1000 tons daily.

The ore deposits at Zellidja, Touisset and Nord Africaine have some similarity to those in Southeast Missouri, but considered as a whole, the area is marked by quite definite zoning. The ores in the Touisset mine which lies to the west of Zellidja, con-

tain relatively little zinc; and those of Nord Africaine to the east, are primarily zinc with a relatively low lead content. The ore which Zellidja is now milling and which is more or less representative of the bulk of the known reserves, runs about 4 pct lead and about 3 to 3.5 pct zinc.

The Zellidja company, in association with Penaroya has constructed at Oued El Heimer, about 16 kilometers from the mine, a Scotch Hearth smelting plant with 10 Neuman hearths. A lead blast furnace is in the process of construction. Zinc concentrates and any excess lead concentrates from Zellidja, are trucked to the railroad at Oued El Heimer and shipped some 60 miles to the Port of Neumours just over the Moroccan line in Algiers. Touisset concentrates and the zinc concentrates from Nord Africaine will be handled in the same manner.

Morocco is, of course, within the French Colonial Empire, and heretofore, with minor exceptions, most production moved to French or Belgian smelters and was disposed of within France. It is unlikely that there will be any substantial movement of either metal or concentrates direct from North Africa to the United States, although indirectly repayment of E.C.A. loans to the Zellidja company will be made by a portion of this production over the period of the next five or six years.

MR. MECHLIN is Vice-President of St. Joseph Lead Co., in New York City. He is a member of the AIME.

Books for Engineers

Introduction to Geology, by E. B. Branson, W. A. Tarr, and W. D. Keller, revised by Carl C. Branson. McGraw-Hill, 1952. \$5.50.—Dealing with physical and historical geology, the book has been revised from an earlier edition. An attempt has been made to eliminate unnecessary detail in discussing processes and history. Revisions bring technical and statistical data up-to-date, and follow suggestions by teachers who used earlier editions. The book carries an eye witness account of the severe earthquake in Assam, India, in 1950 and the story of Paricutin and other major examples of volcanism. Charts summarize chemical weathering, and the results of metamorphisms. The book also contains many new illustrations, including aerial photographs.

A History of Phelps Dodge 1834-1950, by Robert Glass Cleland. Alfred A. Knopf, 1952. \$4.00.—The book traces the growth of Phelps Dodge from the day Anson Greene Phelps opened a small saddle shop in Hartford, Conn., to the present day. As the country grew, so did Phelps Dodge. The company took part in large affairs from its very beginning. It bought and sold, exported and imported, built factories and railroads, and widened its scope of operations economically and geographically. Entrance of Phelps Dodge into copper mining and the gradual giving up of other interests in favor of the new venture is traced.

Handbook of Engineering, by Ovid W. Eshbach. John Wiley & Sons, 1952. \$10.00.—The purpose of the handbook is to embody in a single volume all scientific laws and theories basic to engineering practice. The book contains a summary of all fundamental technology common to nearly all engineering curricula, with only techniques of surveying and drawing omitted.

Mining Year Book—1952, compiled and published by Walter E. Skinner. \$7.00.—This is the 66th annual issue of a standard reference work. It contains up-to-date information on 950 companies operating in all parts of the world, together with a listing of names and addresses of 1100 mining engineers and mine managers and their companies. Company directors and officials are also given. Description of the plant and property, operating results, capital and dividends and financial results are contained in the book.

Engineers and Ivory Towers, by Hardy Cross, Edited and arranged by Robert C. Goodpasture. McGraw-Hill, 1952. \$3.00, 141 pp.—The contents of the book are culled from the writing of Hardy Cross, and reflect

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the author's opinion of the engineer and his relation to humanity. The book touches on a wide range of subjects, including education, graduate study, the application of standardization, and responsibilities and obligations of engineers. The book attempts to evaluate engineering progress, its contributions and its limitations.

Mineral Forecast 2000 A.D., by Edward Steidle. State College, Pa., 1952. \$3.00, 216 pp.—The book foresees an ever-expanding U. S. economy in the next 50 years. It reviews our dependence on outside sources for many strategic and critical mineral supplies. It also outlines the urgent need for conservation of minerals. It makes a case for a Federal Department of Mineral Industries with a Secretary of Cabinet rank. Forecasts are presented for mineral fuels, metallic minerals, and nonmetallic minerals, and their discovery, extraction, preparation, processing, and utilization.

Analytical Mechanics for Engineers, fourth edition, by Fred B. Seely and Newton E. Ensign. John Wiley & Sons, Inc., 1952. \$5.00, 443 pp.—Mechanical principles essential to engineers are presented in four sections: Statistics, kinematics, kinetics, and special topics of vibrations and balancing. The book aims to develop principles from experience, to apply them to practical problems and to emphasize their physical interpretations. New illustrative problems have been added, and material revised in accordance with current ideas.

Dana's Manual of Mineralogy, 16th edition, revised by Cornelius S. Hurlbut, Jr. John Wiley & Sons, Inc. \$6.00, 530 pp.—Alterations and additions have been made to bring this standard volume up-to-date. Past its one-hundredth year of publication, it covers: introduction to mineralogy; chemical mineralogy, descriptive mineralogy; occurrence and association of minerals; mineral uses; and determinative mineralogy.

Intermediate College Mechanics, by Dan Edwin Christie. McGraw-Hill, 1952. \$7.00, 454 pp.—The book emphasizes the vectorial treatment, and treats vector algebra in the first two chapters. Basic material in an elementary mechanics course is developed, the outline for which is determined by major physical concepts. The remaining chapters deal with

selected topics in mechanical physics as vibration, deformation, hydrodynamics, wave motion, and others.

International Conference About Rock Pressure and Support in the Workings. Institut National de l'Industrie Charbonniere, Belgium. 200 Francs, 475 pp.—Forty-two papers presented at the conference are presented in the book under the following headings: rock pressure and movements around the face; measurements of rock pressure and movements; observations and practical notes; methods of support at the coal-face; methods of support of roadways; roof bolting; roof-bursts, water and gas influx, and falls of ground. All articles are in English, French and German editions are available.

Principles of Geochemistry, by Brian Mason. John Wiley & Sons, 1952. \$5.00, 276 pp.—The author presents a description of subject matter, followed by a logical account of the earth's pregeological history, utilizing new data on the abundance of elements and isotopes in the earth and universe. The book goes into detailed discussion of the geochemistry of igneous, sedimentary, and metamorphic rocks, the origin and evolution of the ocean, and the role of organisms in the concentration and deposition of individual elements. Stress is placed on the need for greater effort in interpreting geological data in terms of the principles of physics and chemistry.

Manual of ASTM Standards on Refractory Materials, Prepared by ASTM Committee on Refractories. American Society for Testing Materials, 1952. \$3.00, 294 pp.—In addition to the latest approved forms of 37 standard and tentative specifications the current edition of this manual includes other pertinent information of value in the testing and use of refractories. The book contains suggested procedures in petrographic techniques and for calculating heat losses through furnace walls, standard samples for chemical analysis, industrial surveys of service conditions of refractories and a proposed glossary.

Principles of Petroleum Geology, by E. N. Teratsoo. McGraw-Hill, 1952. \$7.50, 449 pp.—The book is intended for geology students and all those concerned with the oil business. It covers both academic questions related to origin, migration, and accumulation of petroleum in the subsurface, and the practical problems of discovering and exploiting deposits. Treatment is given surface methods, aerial survey and the evaluation of oil seepages and asphalt deposits.

Experiments With an Underground Auger

by J. P. Newell and R. W. Storey

This paper deals with a trial operation in underground auger mining with a machine especially developed for this purpose. The experiment was carried out in a thin coal seam with bad roof conditions. Total elapsed time of the operation was about 10 months, ending in August, 1951.

AUGER mining is a form of continuous mining in that it completely replaces with a one-cycle operation the older conventional cut, drill, shoot, and load method of mining. Relatively new, having been utilized only within the last few years, it is even more continuous in its production of coal than some other forms of continuous mining being practiced in this country today.

There are at present coal recovery augers in operation working along strip-mined highwalls from the outside. This paper will deal with underground mining, specifically with an experiment which was carried out with a machine developed for this purpose.

The location of this experiment was in Pike County in eastern Kentucky in the upper split of the No. 3 Elkhorn seam. Coal height was 32 in. and roof conditions were very bad, with 10 in. of soft draw slate coming down with every cut in conventional mining. The coal is high-grade bituminous, excellent for metallurgical coking.

Underground auger mining fills a need for a method of recovering coal in thin seams, under bad roof conditions or in split seams. In many cases it might save money by eliminating the handling of excessive quantities of rock. In fact, if the coal can be recovered, as in the case of this experiment, without mixing with any impurities outside the seam, it may be possible to load or ship a satisfactory

product with little or no preparation or cleaning expense. The need for some economical method for recovering coal from thin seams is becoming more pressing as the more profitably mined seams are exhausted.

Basic Principles of Auger Mining

The principles of the auger, or screw conveyor, have long been used in drilling small diameter holes for blasting and other purposes. These same fundamentals apply to large diameter drilling. However, considerably more attention was given to designing a cutting head that would not pulverize the coal and consequently would require a minimum of power to drive it.

The head, as designed for this job, consists of a cylinder 25 in. in diam with steel bits set in 3 positions spaced around the forward rim. A conventional coal drill bit, at the head of a bursting cone in the center of the cylinder, trails the forward rim slightly, see Fig. 1. The bursting cone and auger connections are anchored to the cutter barrel by 3 arms spaced at 120°. This head design proved to be very satis-

J. P. NEWELL and R. W. STOREY are with Consolidation Coal Co. (Ky.), Jenkins, Ky.

Discussion on this paper, TP 3334F, may be sent (2 copies) to AIME before Aug. 31, 1952. Manuscript, July 27, 1951. New York Meeting, February 1952.



Fig. 1—The drilling head.

factory in producing lump coal as shown by the following screen analysis:

Screen Hole Diam. In.	Per cent
8 x 5	13
8 x 3	11
3 x 1	22
1 x 1/4	4
5/8 x 1/8	12
5/8 x 3/16	14
3/16 x 0	24
	100

Results such as this were found to be obtainable only when cutting at full speed. If a slower drilling rate is used because of weak pressure or dull bits, there is a heavy transfer from the 3x3/16-in. size range to 3/16x0-in. range. The +3-in. size is affected only slightly.

In drilling, the head has a tendency to drift to the



Fig. 3—Drilling head starting into coal. Note lugs around rear edge of head, designed to relieve any downward pressure from the cutting teeth.

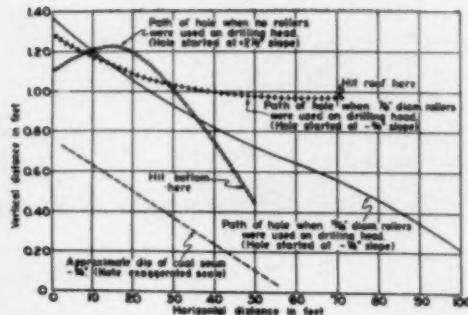


Fig. 2—Typical curves of holes using various methods of controlling vertical movement of head.

right because of clockwise rotation. However, this was not serious since the drift was substantially the same in every hole and the holes remained parallel. Another characteristic of the head as it was originally designed did give considerable trouble: a dip or downward curve in the path of the head was so steep that even with the maximum upward angle short, or penetrating the roof, the holes hit bottom within 40 to 50 ft. Once the head was started into the hole no means was found to influence its direction, either by fast or slow drilling or by changing the angle or elevation of the machine.

Levels were run on the top of each hole (to discount the effect of abrasion on the bottom) and results plotted on a graph, see Fig. 2. The curves of all holes drilled with the same head were similar in shape. This similarity gave some hope that a very uniform performance might be expected after a solution to the dropping curve could be found.

It was thought that if some means were found to remove any downward pressure from the forward end of the cutting head, especially the weight of the head itself, the curved path of the hole could be flattened. This was accomplished by welding a series of lugs around the outside of the cylinder approximately 2 ft back from the cutting edge, as illustrated in Fig. 3. This would give a fulcrum, so to speak, upon which the cutting edge could be cantilevered upward, thus raising the teeth up from the bottom of the hole. It was found that varying the size of these lugs not only flattened the curve but also caused it to curve upward; the larger the lugs the more upward the curve. These lugs seriously reduced drilling speed so that later they were changed to the solid steel rollers shown in Fig. 4. These are similar to spherical roller bearings and are 13/16 in. in diam and 1 1/8 in. long.

Experimentation with the rollers to get them set in the right position proved that holes of 90 to 115 ft could be drilled without cutting into top or bottom.

Construction and Operation of the Drilling Machine

The machine used in this experiment was a Carodox-Hardsoc underground coal recovery drill demonstrated in Fig. 5. It is 24 in. high, 10 1/2 ft long in direction of drilling, and 6 ft 4 in. wide, weighing 8000 lb. It is powered by a 25-hp permissible, 250-v D. C. motor driving through a fluid coupling, see Fig. 6. A clutch, a forward and reverse gear box, a chain drive, and a square bar deliver the power to the drive chuck transmission, which travels 6 1/2 ft along the square bar as the head is pushed



Fig. 4—Rear view of cutting head showing rollers used to support weight of head.

into the coal, giving a rotation speed of 45 rpm, Fig. 7. There is a drive chuck on either side of the transmission, so that by reversing the rotation and using a second set of augers with reverse scrolls to deliver coal on the outby side the operator can drill on both sides of the entry without turning the machine around.

The 25-hp motor also drives a hydraulic pump which furnishes an 18,000-lb thrust, or pull, on the drive chuck, engages and disengages the clutch, operates the gear shift, and raises and lowers the four floor and three roof jacks. The former are necessary to place the head the proper distance from the top and bottom of the seam and at the correct angle, while the latter hold the machine rigidly in position so it cannot shift out of line while drilling. Needle valves lock the jacks once the machine has been set. The frame of the machine is of all-welded steel pipe construction serving also as a reservoir for the hydraulic oil and a housing for the roof and floor jacks, thrust jacks, and cables.

For moving long distances the machine is equipped with detachable rubber-tired wheels on which it can readily be pulled. For short moves from hole to hole there are two pairs of small double-flanged rollers on the bottom of the frame. Thus while the machine is raised on the floor jacks, two sections of light rail may be placed under these rollers. After the jacks are withdrawn the machine can be rolled to the next drilling position; by slightly raising the inby end of the rails one man can accomplish this moving easily. There is also a roller-bearing turntable under the machine which is used to correct any misalignment or to turn the machine 90° or more if necessary.

A puller bar, see Fig. 8, extending from the machine approximately the distance of the hole centers is bolted to the drive chuck transmission. This may be detached during long moves of the drilling machine, see Fig. 9. A hook and chain allow coupling to the string of augers in the completed hole, and by using a second drill head the operator may recover the string a section at a time and use it in the new hole as it is being drilled. This feature prevents cluttering up the operating entry with auger sections and saves time in getting ready to move to the next drilling position when a hole is completed. In other words, there is very little lost



Fig. 5—The drilling machine.

motion or nonproductive time once drilling has begun on a certain length of rib line.

Since the auger delivers its coal at the mouth of the hole on the side opposite the direction of rotation, it may be a problem to pick up the coal and get it to another means of transportation. In this case, where no bottom was taken, a shaker conveyor was used for the purpose, see Fig. 10. A flat pan about 3 ft wide attached to the end of the shaker was placed immediately under the auger string and against the rib. This removed the coal from the scrolls before it travelled more than a foot or two.

Since drilling was done on one side of the entry only, in this case the shaker was very satisfactory. However, this arrangement would present some serious problems if drilling on both sides were contemplated. Possibly some conveyor arrangement could be devised that would not be too cumbersome and would pick coal up from the augers on each side of the entry. This is a much needed feature of the machine that to date has not been satisfactorily achieved for all conditions.

Possibilities and Limitations of Projected Methods

For any system of mining it is generally more economical to get a maximum amount of coal with a minimum amount of development or dead work. This is true in the case of auger mining. For this



Fig. 6—The drilling machine showing string of augers coupled to the drive chuck transmission.



Fig. 7—The drive chuck transmission. Note chucks for drilling in both directions.

reason it is desirable to get maximum length or depth of holes, to be able to drill holes alternately or at the same time on both sides of an entry, and to get a maximum percentage of recovery from the territory developed.

This experiment has proved that under uniform seam conditions of slope and height, holes of at least 100 ft may be anticipated. Rolling or other adverse seam conditions could materially reduce this figure. Also, available power in the drilling machine would limit the depth to which holes could be drilled, although no accurate data on power required were derived from this experiment.

It has been explained previously that the machine used in this instance could drill holes alternately on both sides of an entry. It is entirely feasible that a machine could be developed that would drill on both sides at the same time. This feature in itself brings up the problem of how to develop a territory



Fig. 8—Puller bar fastened to drive chuck transmission.

leaving 100-ft wide pillars for drilling on both sides of the entries and still remain within allowable limitations of ventilation. This may be accomplished by driving entries 200 ft apart and drilling auger holes for air as the entries are advanced, as will be seen in some tentative projections.

The highest practicable recovery will vary from 45 to 55 pct according to seam height and other conditions, owing to the fact that an auger some 6 in. less in diam than the seam height must be selected and pillars of 4 to 8 in. must be left between holes for roof support. A recovery of 50 pct is probably average.

Fig. 11 shows a system of auger mining wherein entries are driven two or three at a time in the conventional manner, with blocks 100x200 ft, one on each side of a single entry, being left for drilling. This system requires a considerable amount of development but may be economical if seam conditions are more favorable toward conventional methods of mining. An advantage is that a considerable territory could be developed ahead of the actual auger mining. Also, ventilation could be kept up by the usual methods, and no auger would be kept in the entry during development.

Fig. 12 shows a system that should be more readily adaptable to thin seam or bad top conditions, since it lends itself to a relatively high production from a concentrated area and requires much less development per ton of auger-mined coal recovered.



Fig. 9—Pulling a section of auger from the completed hole.



Fig. 10—Shaker conveyor used for transportation of coal from the augers.

Table I. Evaluation of Time Factors in Auger Mining

	Min per Hole
Moving of drill from previous hole, once every 2 holes	7
Leveling and locking drill	5
Starting hole and removing Kelly bar	7
Drilling 100 ft at 0.41 min per ft	41
Retrieving and inserting 16 auger sections	18
Minor delays, 10 pct added	8
Total time per 100-ft hole	88

However, it demands that a machine be available continually for drilling ventilation crosscuts as the entries advance. This projection is far from complete and some serious problems of ventilation have not as yet been solved.

While no details have been shown in either of these systems it is entirely possible that some of the development could be done by auger mining equipment. This might be accomplished by drilling several parallel holes straight ahead and then using some means of removing the pillars between holes to make an entry of whatever width is required. It remains to be seen whether or not this method of entry driving would be practical.

There are, no doubt, other systems of auger mining that will be devised. For instance, it might be adapted very readily to a seam where parting is too thick to allow profitable mining by conventional methods. Such conditions could justify an entirely different approach to the subject of projections, development, and various other factors.

Economics of Underground Auger Mining

For the purposes of this experiment an entry 700 ft long was prepared, with solid coal on one side, and while several difficulties were encountered that impeded the project, a complete time study was made on the drilling of 54 holes. This used up about 150 ft of the entry. The remaining distance was drilled without keeping exact time study records, but the first 54 holes provided sufficient data to make reliable production estimates. Evaluation of the time study data showed that certain results could be expected, see Table I.

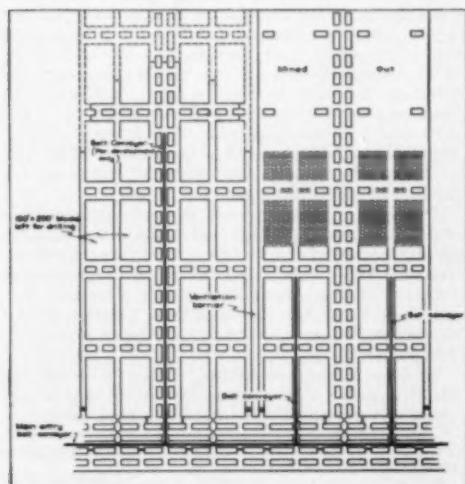


Fig. 11—Projection for a system of auger mining wherein entry development is by conventional mining methods.

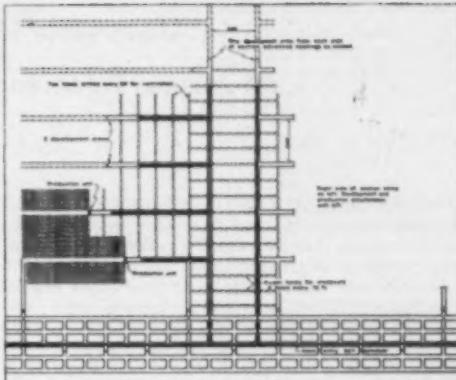


Fig. 12—Projection for a system of auger mining incorporating a very low ratio of development to production.

With 420 min of work time per shift this would allow 4.9 holes per unit per shift to be drilled. On this basis, using a 25-in. diam cutting head, a production of 13.6 tons per hole or 66.6 tons per unit shift would be realized.

Probably the best way to show what production and economy could be expected from underground auger mining would be to assume a complete section, such as that shown in Fig. 12. This theoretical section would employ eight coal recovery augers and four development units. Actually only four of these augers would be on full production of coal at any given time, the other four being kept on hand by development crews for drilling ventilation crosscuts. If a 25-in. diam cutting head is used, assuming a coal height of 30 to 32 in., production is estimated as shown in Table II. The figures would resolve into 967 tons daily, at 12.3 tons per man-shift on the section. At 80 pct performance the production would be 774 tons.

If seam height were such that larger diameter holes could be drilled the production per unit would increase greatly. For instance, if drilling 37 in. diam holes were feasible, using four machines on three shifts, coal production could reasonably be estimated at a total of 1980 tons per day, with full production at 1750 tons and development recovery at 230 tons. An 80-pct performance would give 1584 tons and on the basis of an assumed 21-man section would mean a production of 25.1 tons per man-shift.

The preceding figures show some very interesting possibilities. Just where the practical limit of hole diameters would be is a matter that will probably be established in the future as the underground mining of coal by auger methods becomes further advanced.

Table II. Estimated Personnel and Production Rates Per Section for a System of Auger Mining

Required Crew	Men per Shift	Daily Production, Four Units on Three Shifts
Drill operators and helpers	8	Full production
Development operators and helpers	8	Development tonnage recovered from entries and crosscuts
Class I and utility men	3	
Repair man	1	
Misc. (pumper, electrician, etc.)	1	
Section foreman	1	Total
Total personnel	21	66.6

Deep Hole Prospect Drilling

At Miami, Tiger, and San Manuel, Arizona

by E. F. Reed

CONSIDERABLE deep hole prospect drilling has been done in the last few years in the Globe-Miami mining district about 70 miles east of Phoenix, Arizona, and in the San Manuel-Tiger area about 50 miles south of the Globe-Miami region. More than 205,000 ft of churn drilling have been completed by the San Manuel Copper Corp. at their property in the Old Hat Mining District in southern Pinal County. The deepest hole on this property is 2850 ft; there are 49 holes deeper than 2000 ft. At the adjoining Houghton property of the Anaconda Copper Mining Co., where only one hole reached 2000-ft depth, there were 27,472 ft of churn drilling and 3436 ft of diamond drilling. Three churn drill holes were deepened by diamond drilling methods. Near Miami in the Globe-Miami district the Amico Mining Corp. drilled four holes by combined churn and rotary drilling methods, the total amounting to 13,879 ft, of which 2256 ft were drilled with a portable rotary rig. In the same district, besides doing a large amount of shallow prospect drilling, the Miami Copper Co. drilled two holes of 2560 and 3787 ft, respectively, which were completed by churn drilling methods.

The rocks encountered in drilling at San Manuel and Tiger are described by Steele and Rubly in their paper on the San Manuel Prospect¹ and by Chapman in a report on the San Manuel Copper Deposit.² The rocks are well-consolidated Gila conglomerate, quartz monzonite, and monzonite porphyry. In some places these formations stand very well while being drilled, and three holes were drilled without casing, the deepest of which was 2200 ft. In other holes faulted and fractured ground made drilling difficult.

In the Globe-Miami district the deep drilling was done in the down-faulted block of Gila conglomerate east of the Miami fault and in the underlying Pinal schist. The geology of this area is described by Ransome.³ In the Amico holes the conglomerate varied from material consisting entirely of granite boulders and fragments to a rock made up of schist fragments in a sandy matrix; in the Miami Copper Co. holes there were more granite boulders and the material was poorly consolidated. Drilling was much more difficult and expensive in the Miami area than in the San Manuel district, mainly because of the depth of the holes and the formations drilled.

All the deep hole prospecting described in this paper was done with portable rigs. The churn drill rigs were of several types, of which the Bucyrus-Erie were the most popular. Bucyrus-Erie 28L, 29W, and 36L rigs were used on some of the deeper holes on the San Manuel property. A few Fort Worth spudder types were tried, and the deepest hole at San Manuel was drilled with a Fort Worth Jumbo H. The spudder type is considerably larger than most other rigs used on this work and required a larger location site. The spudders were belt-driven machines with separate power units, and time required for setting up and moving was much longer than with the more portable drills.

All the churn drilling was done by contractors or with machinery leased from them. A few of the contractors had complete equipment, including most of the necessary fishing tools. Unusual and special fishing tools were obtainable from the supply companies in the oil fields of New Mexico or in the Los Angeles area. Most of the contractors used equipment with standard API tool joints, so that much of it was interchangeable.

Failure of tool joints is one of the principal causes of fishing jobs. It can be minimized if the joints are kept to the API specifications and the proper sized joints are used in the various holes. The minimum sizes that should be used with various bits are as follows: 12-in. and larger bits, 4x5-in. tool joints; 10-in. bits, 3 1/4x4 1/4-in. tool joints; 8-in. bits, 2 3/4x3 3/4-in. tool joints; 6-in. bits, 2 1/4x3 1/4-in. tool joints; 4-in. bits, 1 1/2x2 1/2-in. tool joints.

Two rotary drill rigs were tried at San Manuel on the same hole, and a portable rotary drill rig was used on the Amico drilling for test coring the formation and for drilling in holes 3 and 4. Rotary drilling differs from churn drilling or cable tool drilling in that the bit is revolved by a string of drill pipe and the cuttings are removed from the hole by a thin solution of mud pumped through the drill pipe. The principal parts of a rotary rig are the power unit, a rotating table to revolve the drill pipe, hoists to raise and lower the pipe and to handle casing, and a pumping system to circulate the drilling liquid. The rig used on the Amico property at Miami was mounted on a truck. The larger rig used on the San Manuel property was hauled by several trucks and had separate turntable and pumping units.

Diamond drill coring equipment was used successfully with the rotary rig in the holes on the Amico property. To allow for 2 1/2-in. drill pipe with tool joints, 3 1/2-in. core barrels and bits were used. With the standard 3 1/2-in. core barrel there was considerable difficulty in maintaining circulation with mud, so a barrel was designed with a smaller inner tube and a broad-faced bit. This allowed coarser material to circulate between the barrels. Rock bits of 5% to 3% in. were used with the rotary rig for drilling between core runs.

Diamond drill equipment is much lighter than churn drill tools, so that fishing tools can usually be obtained from supply houses by air express when needed. Three churn drill holes on the Houghton property at Tiger were deepened by diamond drilling with Longyear UG Straitline gasoline-driven machines. The open churn drill hole was cased with 2 1/2-in. black pipe.

In deep hole churn drilling, casing is one of the most important items, especially in drilling in unconsolidated material like the formations drilled by

E. F. REED, Member AIME, is a geologist with Anaconda Copper Mining Co., Inspiration, Ariz.

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the Miami Copper Co. and the Amico Mining Corp. At Miami it was furnished by companies. At San Manuel it was furnished by contractors and the company paid for casing which could not be recovered from the holes.

When available, casing for deep wells should be seamless, with API long collar joints and 8 round threads to the inch. Pipe lengths as long as the rig will handle should be obtained. Miami Copper holes were started with 24-in., double-ply 8-gage casing, as the first part of the holes was drilled through tailings. This was followed by 20-in. water well casing. Some 16-in. water well or slip joint casing was used in Amico hole No. 4.

The strings used by Miami Copper Co. allow drilling the deep part of the holes with larger tools and make it possible, when necessary, to complete a hole by running a 4 1/4-in. liner, see Table I. The 6 1/2-in. and 4 1/4-in. strings used by Amico give more clearance. If the hole is advanced much beyond the larger sized casing the 6 1/2 and 4 1/4-in. strings will follow better.

Casing is recovered from a completed hole by driving it up from the bottom with a casing spear while it is being pulled at the top by elevators. When it is too tight in the hole to be recovered it frequently can be loosened if part of the string is cut off. Collar busters and casing rippers will usually cut a string at the required point. Casing can also be parted by blasting, but this often bells out the break and causes further difficulty in recovery.

After the collars and threads were cut off some of the casing used in the first Amico holes it was used again as a butt-welded string in holes 3 and 4. This is at least as strong as thread and collar casing, but if it becomes stuck it is very difficult to recover without rotary casing-cutting equipment. About 85 pct was recovered in the drilling at Miami.

Churn drilling at San Manuel has been described by Steele and Rubly¹ and by Chapman.² Four of the deepest holes on that property were drilled with

Table I. Thread and Collar Casing Used at Miami

Miami Copper Co.		Amico Mining Corp.	
Size, in.	Weight, lb.	Size, in.	Weight, lb.
16	70	12 1/2	54.5
12 1/2	48	10 1/2	44.5
10 1/2	40.5	8 1/2	36
8 1/2	28	6 1/2	26
7	22	6	20
6 1/2	15.5	4 1/2	16

different types of churn drills, with the results shown in Table II.

These figures indicate that in the holes where the longest runs were made the greatest speed of advance was obtained. It is likely that if properly handled the various rigs would have equivalent drilling speeds in the same rock. The Jumbo H takes more time to set up or move than the other rigs but would probably drill just as fast. In recent work at San Manuel a new type of Bucyrus-Erie 36L has been used with a stronger power unit, allowing the handling of heavier strings of casing.

The Bucyrus-Erie 36L type of rig was used on both the Amico drilling and on the two deep holes drilled by Miami Copper Co. Two drill rigs were used simultaneously on both projects, and drilling speed depended on the ground encountered and not on the drill crews. In much of the drilling at Miami it was necessary to lower and underream casing to be sure to reach the depth required. This work was found to entail approximately the same time and cost per foot as the original drilling of the hole. Amico holes 3 and 4 were not underreamed, but neither hole could have been completed by churn drilling to the depth finally reached by rotary drilling methods without considerable underreaming and carrying of casings. In this ground the underreaming method would probably have been less expensive than rotary drilling.

Table III shows the churn drilling performance on the four Amico holes. In No. 1 hole, 1210 hr

Table II. Drilling Results in Four Deep Holes

Hole number	76	86	90	100
Type of rig	B-E 20W	Jumbo H	B-E 36L	B-E 36L
Date started	Sept. 14, 1948	Dec. 19, 1948	Jan. 4, 1949	Dec. 30, 1948
Date completed	Dec. 6, 1947	May 3, 1947	March 3, 1947	Feb. 17, 1948
Shifts worked	396	360	223	142
Total depth	2725	2854	2750	2832
ft per shift	13.2	9.2	12.3	18.6
ft per hr	1.65	1.15	1.34	2.32
Drilled with 12-in. bit	1135	1305	1360	920
10-in. bit	525	765	625	935
8-in. bit	425	185	375	685
6-in. bit	640	635	237	75
5-in. bit			408	
ft drilled, total	2725	2850	2750	2835

Table III. Drilling Results, Amico Mining Corp.

	No. 1 Hole		No. 2 Hole		No. 3 Hole		No. 4 Hole	
	Hr	Total, ft						
Setting up	22	0.3	42	0.8	65	1.0	58	1.3
Drilling	3085	62	2255	50.9	3257	61.0	2607	58.2
Not working								
Reaming	1083	8.4	726	11.3	336	8.1	518	11.7
Preparing tools	96	16.6	1597	24.4	—	—	182	4.4
Fishing	337	5.1	110	1.7	6	0.3	216	4.9
Repairs	57	0.9	96	1.5	111	2.7	86	1.8
Casing	271	4.2	411	6.3	142	3.6	210	4.8
Miscellaneous	183	2.8	92	1.4	62	1.4	—	—
Total	6865	626		4186		4410		
Depth drilled, ft	2872	2915		2789		3087		
ft per hr, pct	0.44	0.45		0.67		0.70		
ft per hr (drilling only), pct	0.73	0.87		0.83		1.03		

Table IV. Drilling Results, Miami Copper Co.

	No. 1 Hole		No. 2 Hole	
	hr	Total, ft	hr	Total, ft
Setting up	194	3.5	34	0.4
Drilling	2563	44.5	5387	63.1
Reaming	701	9.2	1310	15.3
Casing	938	12.2	840	9.8
Fishing	469	6.5	84	1.0
Repairing	100	1.3	129	1.5
Miscellaneous	315	4.1	238	2.8
Not working	1548	17.7	554	6.1
Total	7656	94.4		
Depth drilled	2560	3787		
ft per hr, pct	0.33	0.44		
ft per hr (drilling only), pct	0.72	0.70		

Table V. Diamond Core Drilling from Churn Drill Holes

	Depth, ft		
	Hole 5	Hole 6	Hole 8
Diamond drilling, depth started	1218	1005	1330
BX, depth drilled	1610	1305	1710
BX, no. of ft drilled	393	300	180
Core recovery, pct	39.3	23.2	15.3
Rate of drilling, ft per day	8	8	8
AX, depth drilled	1784	1405	1855
AX, no. of ft drilled	114	100	145
Core recovery, pct	7.2	9.0	13.7
Rate of drilling, ft per day	13	33	24

were lost drilling past a length of 8-in. casing which parted and remained in the hole. The two Miami Copper Co. holes were drilled simultaneously. Drilling performance is shown in Table IV.

Different types of bits and various methods of sharpening them were tried on the Amico work without any definite change in drilling speed, which was faster in holes where fewest hard boulders were found in the conglomerate. A number of crew members who had worked with Amico also drilled the Miami Copper Co. holes, using similar equipment, so that relative drilling speeds were influenced chiefly by the formations encountered.

The conglomerate drilled on the San Manuel property was better consolidated and had fewer boulders than the conglomerate at Miami, and the porphyry formations at San Manuel drilled much faster than the Miami schist. Both formations at San Manuel appeared to stand better. The average advance of each size bit in the four holes shown in Table II was 645 ft, while the average depth of open hole drilled by Miami Copper Co. after landing a string of casing was only 118 ft.

The San Manuel Copper Corp. did not allow the use of drilling mud to seal off the water from the walls and help prevent caving, but it was used in all the holes at Miami. The Miami Copper Co. devised a method of mixing a known amount of barite with the drilling mud so that the samples could be analyzed for barium and the amount of mud dilution of the samples determined. Standard methods of churn drill sampling were used in all the drilling.

Two rotary rigs of the portable type sometimes used in drilling oil wells were tried on hole No. 59 on the San Manuel property to obtain some core for metallurgical tests and geological information. The first proved too small, and only one attempt was made to core in the 945 ft drilled with that rig. The second rig drilled to 1000 ft and cored from 1000 to 1608 ft. The core from a hole of 9% in. was 3 1/2 in. in diam. In all, 108 ft of core were recovered, or 17.76 pct of the depth drilled. Drilling and coring took 12 days, so that the rate of advance was about

50 ft a day. This is considerably faster than churn drill advance, but rock bit costs were excessive.

On the Amico property it was found that the deeper part of the conglomerate formation consisted entirely of schist fragments, so that it became impossible to tell by means of churn drill cuttings whether the holes were in conglomerate or solid schist. When hole No. 1 had been drilled to 2870 ft and hole No. 2 drilled to 2915 ft, it was decided to recover core for proof of solid formation. Diamond drill contractors were unwilling to attempt coring at that depth with equipment available, so a portable rotary rig was obtained. Cores were cut from the bottom of both holes, using 3 1/2-in. diamond drill core barrels and 2 3/8-in. drill pipe. The rotary rig was equipped with special weight indicators and pressure gages to adapt it to diamond drill work. Excellent and conclusive results were obtained, but the work was expensive for the amount of drilling done.

For similar reasons, coring methods with the same equipment were used in Amico holes 3 and 4. These holes were found to be still in conglomerate, and so were drilled between core runs with rotary drill rock bits. The formation was very abrasive and rock bit costs were high, but the holes were completed by this method with satisfactory results. In drilling with rock bits a large proportion of the cuttings were removed from the drilling liquid with a shaker screen; the fines were removed in settling tanks. These materials were used as rough samples of the formations drilled, but all clay material remained in the drilling stream. Core samples were the only satisfactory indication of the values encountered.

A rock bit core barrel was tried in the conglomerate but did not prove satisfactory, as only 15 pct of the core cut was recovered. Core recovery with the diamond drill equipment averaged more than 50 pct and was better in the schist than in the conglomerate.

At the Houghton property near Tiger, three churn drill holes were deepened by diamond drill methods and equipment. The results of this drilling are shown in Table V. The Longyear U. G. Straitline rigs used were capable of drilling in BX and AX sizes at the depths required, so the holes were started by placing 2 1/2-in. standard black pipe in the churn drill holes. This pipe was cemented in at the bottom and stretched at the top to cut down vibration.

Sludge and core samples were weighed and assayed separately, and satisfactory average values were calculated. In work when high core recovery is necessary, this method could be used with heavier equipment and larger diameter core barrels.

Acknowledgments

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Ore Control Methods at Inspiration Consolidated

Copper Company

by J. L. Carne

ORE control is a matter of planning and supervision based on a foreknowledge of the content and distribution of ore. The Inspiration orebody is predominately a copper-sulphide blanket, overlain by an oxidized zone of copper silicates, copper carbonates, and barren capping. Most of the ore is treated by leaching, and the optimum requirement of this method is the goal toward which the mining schedule is aimed. Both open-pit operations and underground mining are used. The problems of ore control at Inspiration are: 1—maintenance of metallurgical balance, 2—conservation of oxide ore, and 3—mining out of the orebody at an average grade which parallels that of the reserve figure.

Prior to the fall of 1926 all of the Inspiration division ores were treated by flotation, but the mixed ores of the Live Oak—Keystone section carried too large a proportion of copper in the form of chrysocolla for satisfactory flotation. For this type of mixed ore the leaching process now in use had been worked out, and the plant was put into operation in the fall of 1926.

The process is known as the ferric sulphate leach, and the leaching solvents contain both ferric sulphate and free sulphuric acid. Sulphide copper in the form of chalcocite is leached by the ferric sulphate, and the oxidized copper minerals are dissolved by the sulphuric acid.

From the beginning of operations to the present time the plant has treated some 67 thousand tons of ore having an average copper content of 1.142 pct, of which 0.605 pct has been in the form of oxidized copper minerals. The plant is currently being operated at the rate of 11,500 tons per day, 7 days per week. However, this tonnage is produced in 6 days of mine operation. The average current grade is approximately 1 pct copper, of which about 50 pct is present as oxidized or acid-soluble copper.

Close control of metallurgical procedures is a vital factor in operation of the plant and is in turn dependent upon careful regulation of feed. An excess of sulphide copper requires the presence of more ferric sulphate in the leaching solvents. On the

other hand, an excess of ferric sulphate in the presence of a low sulphide feed seriously reduces the efficiency of electrolytic precipitation in tank house operations. This condition must be avoided at all costs.

An additional factor must be considered. It is known that the sulphide content is predominant in the ore which remains in the reserve. To maintain the necessary sulphide-oxide proportion, so that the entire reserve will mine out at both a grade and a sulphide-oxide ratio that will be permissible throughout the remaining life of the property, it is obvious that the oxide reserve must be currently preserved to as great an extent as possible.

Fortunately much of the oxide reserve is found in the open-pit operation. This happy circumstance adds flexibility to the procedure and makes it possible to maintain the close regulation necessary to insure best overall results, both mining and metallurgical.

The two ore streams from the pit and underground operations join at the coarse-crushing plant, and proper control must be exercised before the ore reaches this point. The open pit is currently providing about 55 pct of the ore and underground operations the balance of production. Both operations are under a single superintendent so that the closely interrelated problems may be more readily controlled.

The least flexible of the two producing units is the underground mine, where the mining method is block caving. Although a block of ground may be undercut and developed, characteristics of the material determine its caving action. The ore in the chutes must be drawn.

The area currently mined from underground is in a zone predominately sulphide and is generally

J. L. CARNE, Member AIME, is Assistant Chief Mine Engineer, Inspiration Consolidated Copper Co., Inspiration, Ariz.

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overlain with a varying column of carbonates and silicates of lower grade. Under the circumstances, these constitute excellent diluting material. They are in turn covered with a column of leached schist or granite porphyry varying from 200 to 500 ft. The Live Oak 800 level, producing about 4000 tons daily, is typical.

In the mining of the Live Oak 800 level, which has produced several million tons, about 30 pct of the copper has been found to be acid-soluble. This information is not available from the original churn drill logs, and it was only after several years of mining that sludges from subsequent sampling were assayed for oxide and sulphide copper. This was a tremendous forward step in classifying the ore. However, where complete churn drilling data are not available past mining records are the only source of information concerning this important classification. As mining records indicate, 30 pct of the copper that comes from the Live Oak 800 level is oxidized in the ore. An attempt is made to get this proportion daily and not an average of highs and lows. In drawing the blocks it has been found that the first 20 pct of the column will be a very high sulphide, 10 pct or less as oxide; the next 20 pct approximately 20 pct oxide; the following 20 pct about 30 pct oxide, and the final draw assays about 40 pct oxide. With a planned development schedule it is possible to keep one block in the early stages of draw, where drawing is kept at a curtailed rate to get good caving action; two blocks will be in the middle stages of draw, and as good caving action should have taken place by this time, these two blocks will furnish the major portion of production. The fourth block is then in the final stages of life with considerable dilution showing in a majority of the draw points, necessarily limiting the amount of tonnage available. Keeping these producing areas in the above stages of draw prevents the occurrence of slugs of high sulphide from this area. The result is a more uniform character of feed to the leaching plant with better control of the overall oxide-sulphide ratio, which meets the desired condition.

To recapitulate, the basic factors in controlling mined grade from underground sources and maintaining the desired oxide ratio on a day to day average are: 1—a well planned long range development program, with sequence of mining the individual blocks determined by good mining practices, as well as a constant source of production at the overall level grade, and 2—maintenance of the even and planned draw required in the various stages of extraction in any given block.

A careful check is kept on daily underground production by the sampling of the individual train loads from the various blocks, a grab sample being taken from each car before it is dumped. These returns are available to the supervisory staff the morning following sampling. Grab samples are also taken from the stope draw points as needed. This applies particularly when blocks are approaching exhaustion or when dilution has appeared. Quick results are obtainable from the Mine Assay Office, and no draw point need remain idle very long waiting for assay returns. With the information obtained from underground sampling, any necessary change may be made within the level limits to vary the grade, provided that good mining practices are not violated.

At present the open pit produces a higher percentage of acid-soluble copper than the underground

operation. The productive area includes the eastern portion of Live Oak orebody and the entire Keystone orebody. The column in this area has a relatively low back of leached waste, and the greater part of the ore is in the oxidized zone with a lesser column of sulphides on the bottom. In the open pit mining the grade can be mined in place, as no dilution problems exist, but in turn it has been necessary to mine down through the oxidized strata to uncover sulphides. The physical characteristics of this pit currently require mining more oxides than desired in the process of exposing the sulphides. Long range planning requires the uncovering of large tonnages of sulphides in the next few years to take up the loss in production from underground sources, but at the same time the oxide reserve must be nursed.

Within the limits of the ore that is exposed in the pit a very close, day to day control of grade can be imposed. The assaying of the blast hole sludges renders the problem a simple one by avoiding the long interpolations common with the normal grid. The following procedure gives the operating staff a detailed knowledge of the material available for mining. Benches are carried at 50-ft intervals and blast holes drilled 5 to 6 ft below grade with sludge from the first 50 ft going into a sample. Normally, one sample is taken for the entire 50 ft, the sludge first being cut by a modified Jones Rifle sampler, mounted on the deck of the drill, retaining one part in 100. The sample is cut by a small hand rifle sampler into a 1-gal bucket, retaining one part in two. The assay values of the sludges are then recorded on the bench assay plans. These are blocked out by blasts averaging 35,000 tons, and the total copper and acid-soluble copper are calculated by averaging numerically the value of the holes in the blast. A broken reserve of 200,000 tons of ore is about normal. The approximate grade of material that will be taken from the mine, coupled with the accurate information of the broken ore on the benches, indicates the digging area on the bench or benches.

For the first ten months of mining in 1951 the grade has averaged 1.022 pct in total copper, of which 0.471 pct is acid-soluble, to be compared with a planned grade at 1.00 pct total copper with 0.40 pct acid-soluble. In total copper this is an extremely close control, considering the variable ground that has to be mined. The acid-soluble copper is higher than desired, but the current schedule in pit mining will give a more flexible control of this phase during the coming year.

The major reserves of sulphide in the open pit lie in the Inspiration division, or eastern section of the orebody. For the past year stripping of this area has been pushed, so by early 1952 the sulphides necessary to hold the overall oxide content to the required minimum can be furnished from the pit. As long as the underground production is limited, and exposed reserves in the open pit contain extremely high oxides, the difficulty in control is keeping the oxide ratio down to the minimum requirements until such time as the sulphides are available in the open pit.

It is safe to say that Inspiration has a unique problem in ore control. For successful and most efficient extraction of the entire remaining ore reserve, great care must be exercised concerning both grade and oxide-sulphide content of the ore as mined.

Some Effects of Sewickley Seam Mining on Later Pittsburgh Seam Mining

by F. R. Zachar

Unmined blocks in the Sewickley seam, surrounded by worked out areas, have been found to transmit overburden loads through the interval strata to the Pittsburgh seam workings 90 ft below. Operating experiences under these conditions are described in this paper.

IT has always been understood, in northern West Virginia where both the Pittsburgh and Sewickley seams are mined, that pillarizing or splitting in the lower Pittsburgh seam could break the interval strata and make mining in the overlying Sewickley difficult or impossible. In some instances, however, mining methods practiced in the overlying Sewickley have reversed the problem, resulting in a shifting of the intermediate layer and destroying valuable acreages of the Pittsburgh seam below.

The Pittsburgh seam in this area is, on the average, 102 in. thick. About 18 in. of low-quality head coal are left for roof protection as it is mined. Immediately over the coal are two draw slates, two rider seams, and a good hard black shale, locally called black rock, which serves as a permanent roof where draw slates and riders are taken down on certain main haulroads. In most areas mined in this seam in the past the bottom has been satisfactory but soft. However, in areas now being mined by the Christopher Coal Co. in Monongalia County the bottom is very hard and unyielding.

The Sewickley seam, lying 85 ft above the Pittsburgh, will average nearly 70 in. in thickness and is overlain by massive shales and sandstones. Much of the seam is mined only down to the "sheep skin," a hard band about 4 in. above the bottom, which is composed of relatively hard shale. Fig. 1 shows a typical cross-section through the Pittsburgh and Sewickley seams in the area being discussed. The thin Redstone seam is not deep-mined but is stripped in some locations where it outcrops.

Most of the Sewickley seam in the Morgantown areas has been mined out from 10 to 30 years. There are at present only two large mines and five or six

others of small production operating in that seam. Mining systems in the past were generally of the room and pillar type with some full pillar extraction. This seam in the Scott's Run area was operated by as many as thirty or forty different companies at one time, during an era beset with strikes, market failures, and depressions. Most of the barrier pillars along the many main haulroads were abandoned, and blocks of Sewickley coal that would be fully recovered with today's machinery were left unmined when conditions became anything less than favorable. Consequently the mined-out Sewickley is spotted throughout with solid blocks varying in size from 100x100 ft to 200x400 ft and larger. It is these unmined Sewickley blocks surrounded by worked-out portions that have caused transmissions of roof stresses to underlying Pittsburgh mining areas, see Fig. 2, resulting in untold difficulty.

As the Christopher Coal Co. operates both the Pittsburgh and Sewickley seams, accurate maps of workings in both seams are readily available and are regularly consulted. The first Pittsburgh squeeze attributed to overlying Sewickley blocks occurred in the Arkwright mine, where a shuttle car crew was developing a section consisting of seven panel headings. These entries were being driven in solid coal 3400 ft from the nearest worked-out Pittsburgh area. As mining advanced it was noticed that certain ribs began to slough and certain areas to show signs

F. R. ZACHAR, Member AIME, is General Superintendent with the Christopher Coal Co., Purglove, W. Va.

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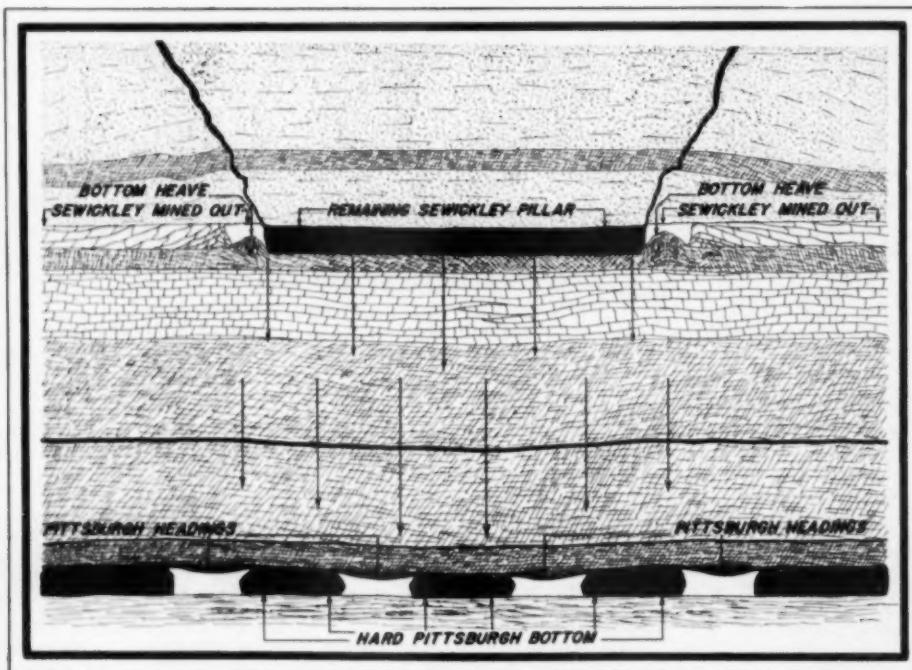
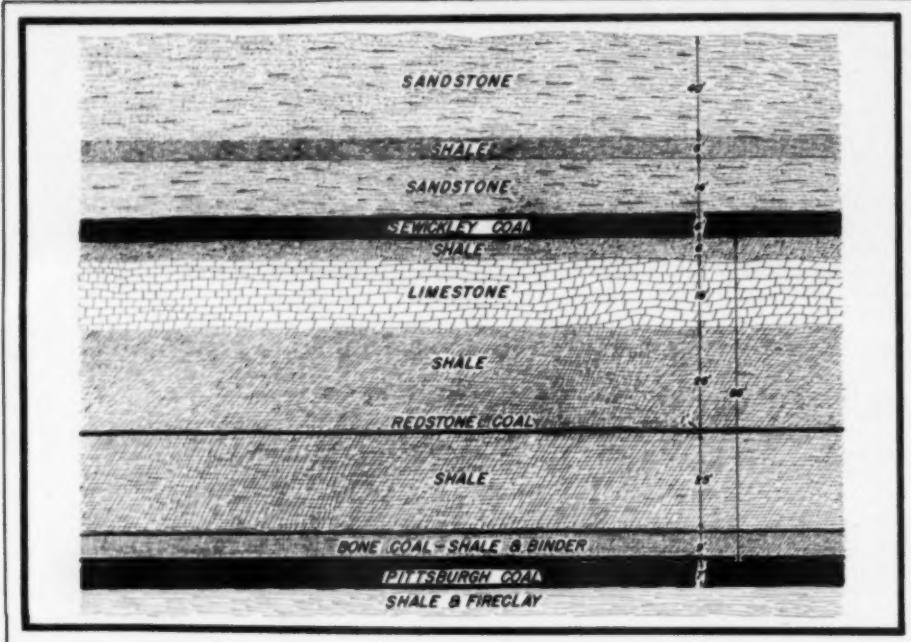


Fig. 1—A typical cross-section showing strata overlying the Pittsburgh coal. Fig. 2—Overburden load transmission to the Pittsburgh seam through unmined Seewickley blocks.

of roof breaks along the ribs. Finally, when the section had been developed to the extent shown in Fig. 3, it was necessarily abandoned and all material and equipment removed because the return air courses could not be kept open. Examination of an overlay map showing both Pittsburgh and Sewickley seams illustrated with remarkable clarity that the squeeze areas in the Pittsburgh were directly under large blocks left unmined in the Sewickley. This is revealed in Fig. 3, where crosshatched lines show squeezed ribs and dotted lines indicate the blocks remaining in the Sewickley seam.

The sketch in Fig. 2 shows what the writer and others believe was the cause of the squeeze. It is their contention that the overburden load pushes the Sewickley block down into its soft bottom. This soft bottom heaves; consequently the ribs of the block do not crush. The load is transmitted through the interval strata to the Pittsburgh below. The Pittsburgh bottom in this area is extremely hard, and inasmuch as it does not crack and heave, the ribs crush and break and the roof breaks over them, as shown in Fig. 2. It is thought that the extremely hard Pittsburgh bottom is altogether responsible for the rib and roof failures in that seam where workings pass under unmined blocks in the Sewickley.

Depth of Sewickley overburden plays an important part in these squeezes. Where the Sewickley cover varied from 50 to 200 ft little difficulty has been encountered in the Pittsburgh seam under the remaining Sewickley blocks. Where Sewickley cover is in excess of 200 ft, however, squeezes can be expected, and where the cover exceeds 300 ft difficulties are almost certain in the Pittsburgh seam under the blocks described.

Another group of headings in the Arkwright mine reacted to the overlying Sewickley blocks in much the same way as those described above. These headings were very difficult to mine where they passed

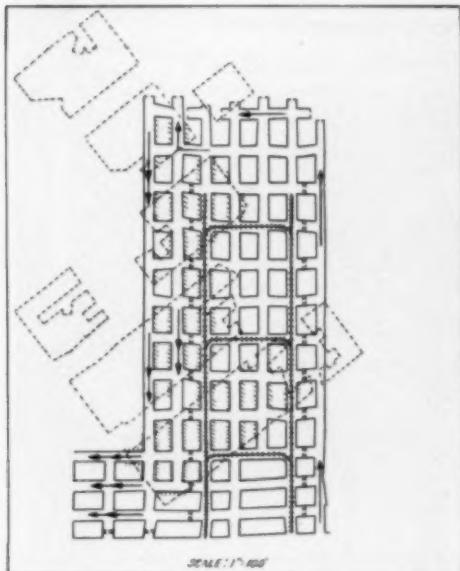


Fig. 3—Squeezed Pittsburgh headings under Sewickley blocks.

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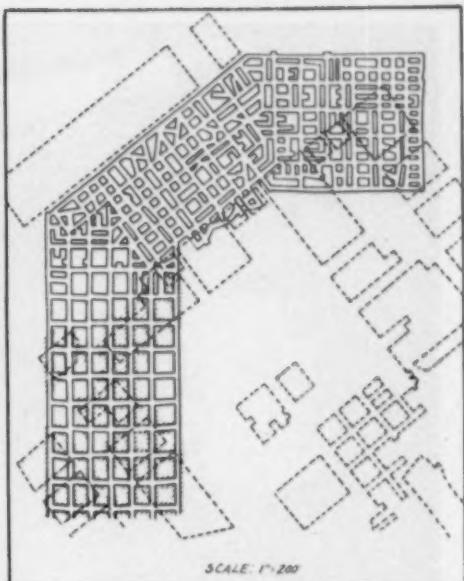


Fig. 4—Squeezed Pittsburgh headings under Sewickley blocks.

under the blocks, but when they were turned to go between rows of overlying blocks they became normal and profitable to develop and retreat. In Fig. 4 these headings may be seen, together with overlying Sewickley blocks. Here again the crosshatched lines represent the squeeze areas. It was not possible to split the blocks back beyond those shown. Roof failure caused by squeezed ribs is illustrated by Fig. 5 and the manner in which the ribs crush by Fig. 6, a photograph of a corner in the Pittsburgh headings that lie directly under a large Sewickley block. These two photographs were taken in the now abandoned headings in solid coal shown in Fig. 3.

Difficulties in keeping haulways open where they pass under these overlying solid blocks can best be shown by the cribbing, see Fig. 7, necessary to maintain the haulway of the section, shown in Fig. 4, developing solid acreage 3000 ft from the nearest worked-out Pittsburgh area. The entry was driven 16 ft wide and all crosscut intersections were roof-bolted with conventional timbers on 4-ft centers between crosscuts. Rib spalling became so severe that in places the entry widened itself to nearly 24 ft. The cribbing shown was necessary to sustain the ribs and to provide cross timber supports. Note how the 6-in. steel H beams are bowed and the wooden beams broken. The steel beams were placed when it became apparent that the squeeze was threatening the entry.

Roof bolting has proved helpful in postponing final caving of headings under these conditions but has stopped neither the final cave nor the squeeze. The entries shown in Fig. 3 were completely roof-bolted with six bolts anchored securely in the black rock to the cut. As the rib failures increased the places widened, and after widening to around 22 ft the black rock sheared at the ribs, causing the entire place to fall and bringing the roof bolts down



Fig. 5 (Above)—Rib failure on a corner of the Arkwright mine. Fig. 6 (Lower left)—An example of roof failure in the Arkwright mine. Fig. 7 (Lower right)—Cribbing installed in the Arkwright mine to protect the West haulway.

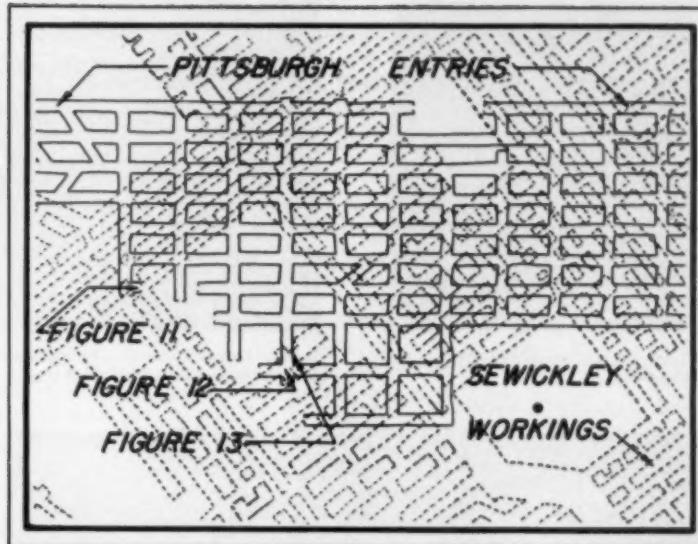


Fig. 8—Squeeze area in Osage mine with overlying Sewickley.

at the same time. Roof bolting does have the advantage, however, of giving mine management more time to install cribs or steel beams, whereas ordinary wood crossbars take the weight so rapidly that they sag and it is difficult or impossible to work under them.

The Osage mine of the Christopher Coal Co. is adjacent to the Arkwright mine, and its development sections are in the same general area. Until recently it has been worked successfully under old Sewickley mines. The past Osage workings were in areas where the Pittsburgh seam bottom was soft and where loads transmitted from the Sewickley above merely caused bottom heave and hence no crushing of the ribs. However, Osage is now developing an area under the old Brock mine workings where the Pittsburgh bottom is extremely hard. In an attempt to develop the main headings of the mine Osage was forced to abandon four headings and to change from off-track to track-mounted equipment to get these entries advanced to a desired point.

Fig. 8 shows the Osage Main West headings and two large overlying blocks of Sewickley coal. The entries under the larger of the two blocks finally had to be stopped, as the squeeze condition became too difficult to work. It will be seen that owing to the same difficulty the outside air course under the smaller block was never driven.

Fig. 9 shows the first stages of rib failure in this area of the Osage mine. This section was entirely roof-bolted but had to be cross-timbered to reinforce the bolts and finally center-posted as shown. Fig. 10 shows later stages of rib failure with beginnings of roof failure on this same entry. Note how deeply the crushing has penetrated the rib and how the roof is breaking away from the bolts in the background. This entry later fell in completely and had to be abandoned.

Further examination of the cause of these squeezes, carried out in the Sewickley seam old works in the Brock mine, revealed at first hand conditions of the entries adjacent to large remaining blocks causing Pittsburgh seam troubles. A study



Fig. 9—Early stage of rib failure in the Osage mine.



Fig. 10—Later stage of rib and roof failure in the Osage mine.

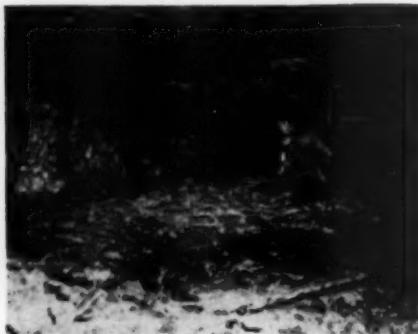


Fig. 11—Bottom heave adjacent to unmined block in the Brock mine, Sewickley seam.

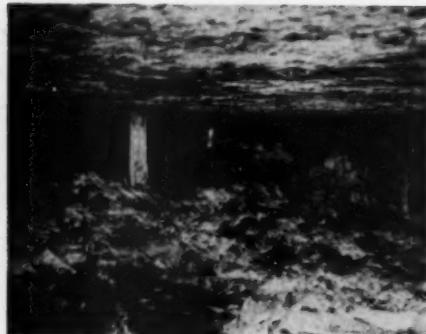


Fig. 12—Extreme bottom heave in the Sewickley seam adjacent to unmined block in the Brock mine.



Fig. 13—Bottom heave in a 38-ft wide room adjacent to unmined block in the Brock mine.

of Figs. 11-13 will prove that all disturbance due to overburden load has been in the soft bottom, leaving ribs and roof in sound repair. The first of these three photographs shows the entry at location 11 on the map in Fig. 8. Note that the bottom has heaved to within 24 in. of the top of a 72-in. seam; observe also the absence of rib spalling and the excellent condition of the roof.

Inasmuch as the squeeze in the Osage mine directly under this general area was the worst of its type encountered, conditions in the overlying Sewickley were thoroughly investigated, with the resulting photographs: Fig. 12, corresponding to location 12 in Fig. 8, shows extreme bottom heave to within 10 in. of the roof and Fig. 13 a bottom heave to within 18 in. of the roof near the ribs. Here again it will be seen that no rib spalling is apparent and the roof shows no evidence of load. A similar examination was made in the Sewickley entries adjacent to the large standing blocks and in the area overlying the squeezes shown in the Arkwright mine, Fig. 4. The same conditions were found throughout. This further bears out the theory that overburden is transmitted through the Sewickley block and interval strata to the Pittsburgh; the Pittsburgh roof and ribs fail because the hard bottom will not break, whereas the Sewickley bottom heave takes the load off the coal and roof. This was shown earlier in Fig. 2.

Not all Pittsburgh difficulties occur in advance mining under old Sewickley workings with standing blocks. One costly experience occurred at Booth No. 6 mine where another company was retreat-mining the Sewickley directly over the Booth main haulway. The Pittsburgh entries were driven on the face and the Sewickley was retreating a panel on the butts. At the point where the retreat crossed over the Pittsburgh, there was a Booth power and water discharge borehole on No. 1 heading and an active gas well 100 ft to the right of No. 5 heading and 600 ft inby the borehole. In retreating, the Sewickley mine left large protection areas around both the borehole and the gas well; when the retreat mining had passed beyond the gas well the Pittsburgh headings below squeezed badly with rib and roof failures requiring extensive steel timbering and cribbing. No information is available as to what damage was done to the gas well, as it had been abandoned for several years. The borehole, however, was destroyed between the seams, and of course at its bottom in the Pittsburgh. Since 100 ft of solid coal surround the gas well where it passes through the Pittsburgh seam, it probably has not been damaged. Undoubtedly several other factors were involved, but it is felt that this is another instance in which Sewickley seam mining affected the underlying Pittsburgh seam.

Adsorption of Sodium Ion on Quartz

by A. M. Gaudin, H. R. Spedden, and P. A. Laxen

WHEN a mineral particle is fractured, bonds between the atoms are broken. The unsatisfied forces that appear at the newly formed surface are considered to be responsible for the adsorption of ions at the mineral surface. A knowledge of the mechanism and extent of ion sorption from solution onto a mineral surface is of interest in the development of the theory of flotation.^{1,2}

Study of the adsorption of sodium from an aqueous solution on quartz offers a simple approach to this complicated problem. The availability of a radioisotope as a tracer element meant that accurate data could be obtained.^{3,4}

Three main factors which appeared likely to affect the adsorption of sodium are: 1—concentration of sodium in the solution, 2—concentration of other cations in the solution, and 3—anions present in the solution.

Hydrogen and hydroxyl ions are always present in an aqueous solution. By controlling the pH, the concentration of these two ions was kept constant. The variation in the amount of sodium adsorbed with variation in sodium concentration was then determined under conditions standardized in regard to hydrogen ion. The effect of concentration of hydrogen ions and of other cations was also measured. A few experiments were made to get a preliminary idea on the effect of anions.

The active isotope of sodium was available as sodium nitrate. Standard sodium nitrate solutions were used throughout these experiments except when the effects of other anions were studied.

It was found that sodium adsorption increased with sodium-ion concentration, but less rapidly than in proportion to it. Increasing hydrogen-ion concentration, or conversely decreasing hydroxyl-ion, brings about a comparatively slight decrease in sodium-ion adsorption. Increasing the concentration of cations other than hydrogen or sodium decreases somewhat the adsorption of sodium ion. It would appear as if the kind of anion is a secondary factor in guiding the amount of sodium ion that is adsorbed.

Materials and Methods

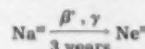
Quartz

The quartz was prepared as in previous work in the Robert H. Richards Mineral Engineering Laboratory⁵ except for the refinement of using de-ionized distilled water for the final washing of the sized quartz, prior to drying.⁶ To minimize the laborious preparation of quartz, experiments were made to determine whether the sodium-covered quartz could be washed free of sodium and re-used. The experiments were successful as indicated by lack of Na^+ activity on the repurified material and by its characteristic sodium adsorption.

Table I gives the spectrographic analyses of the quartz used. The quartz ranged from 16 to 40 microns in size, averaging about 23 microns (microscope measurement), and had a surface of 1850 sq cm per g (lot I), 2210 (lot II) and 2000 (lot III) as determined by the Bloecher method.⁷

Radioactive Sodium

Method of Beta Counting for Adsorbed Sodium: Na^{22} , the radioisotope of sodium, possesses convenient properties.⁸ It has a half-life of 3 years, thus requiring no allowance for decay during an experiment. On decay it emits a 0.575 mev β radiation and a 1.30 mev γ radiation. The decay scheme is illustrated in the following equation:



The β radiation is sufficiently strong to penetrate an end-window type of Geiger-Mueller counting tube. This, in turn, makes it possible to use external counting, a great advantage in technique. Furthermore, it permits the assaying of solids arranged in infinite thickness, while assaying evaporated liquors on standardized planchets.

The equipment used was standard and similar to that employed by Chang.⁹

The original active material was 1 ml of solution containing 1 millicurie of Na^{22} as nitrate. This active solution was diluted to 1000 ml. Five milliliters of this diluted active solution was found to give a quartz sample a sufficiently high activity for accurate evaluation of the sodium partition in the adsorption measurements. Also, 1 ml of final solution gave a sufficiently high count for precision on the liquor analyses.

The sodium concentration of the diluted active solution was 1.2 mg per liter, so that 6 mg of sodium for 60 ml of test solution and 12 g of quartz was the minimum amount used. The active solution was stored in a Saftepk bottle.

Procedure for Adsorption Tests: The method consisted of agitating 12 g of quartz with 60 ml of solution of known sodium concentration for enough time to establish equilibrium between the solution and the quartz surface. The quartz was separated as completely as possible from the solution by filtering and centrifuging. The activity on the quartz and in the equilibrium solution was measured and the partition of the sodium was calculated from the resulting data.

The detailed procedure for the adsorption test is set forth in a thesis by Laxen.¹⁰ In brief, it included the following steps:

1—Ascertainment of linearity between concentration of Na^+ and activity measured.

2—Evaluation of factor to translate activity on solid of infinite thickness in terms of activity on an evaporated active film of minute thickness, on the various shelves of the counter shield.

3—Taking precautions to avoid evaporation of water during centrifuging.

A. M. GAUDIN and H. R. SPEDDEN, Members AIME, are Professor and Assistant Professor of Mineral Engineering, respectively, Massachusetts Institute of Technology, Cambridge, Mass. P. A. LAXEN, Student Associate AIME, is now in Transvaal, South Africa.

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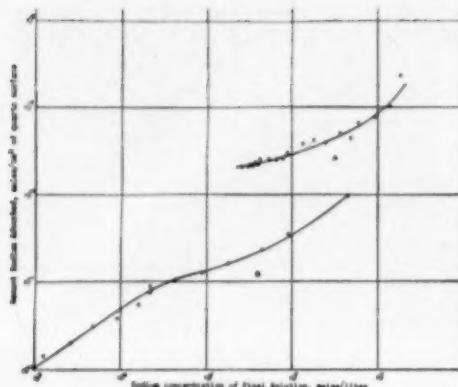


Fig. 1—Adsorption of sodium on quartz. Curve A shows effect of Na^+ concentration of pH 10. Curve B shows effect of Na^+ concentration of pH 6.

4—Weighing accurately the moisture retained in the pores of the filter cake and deducting the activity due to this retained solution as well as the background activity from the gross activity observed, so as to obtain the net activity of the coated mineral.

Experimental Results

Attainment of Equilibrium: Three adsorption tests were conducted in which the only variable was the time of agitation. The tests were run for 1, 2, and 3 hr. The results obtained are summarized in Table II. This table shows that the amount adsorbed (col. 4) does not differ from test to test significantly more than the pH (col. 2). As is shown below, the amount abstracted varies as the pH. If the data of col. 4 are corrected to the same pH (9.70) as explained further, these data support the conclusion that agitation for 1 hr is sufficient for equilibrium.

Effect of Na^+ Concentration: Two series of tests were conducted in which the sodium-ion concentration was varied. In one it was aimed to keep the pH at 10 and in the other at 6. Actually, the pH values of the solutions from the first series varied between 9.4 and 10.2, while those in the second series varied between 5.5 and 6.1.

The sodium concentration was varied between 1.95 and 182 millimols per liter in the first series and between 0.00848 and 45.3 millimols per liter in the second series. Lower sodium-ion concentrations in the first series could not be used, as some NaOH was required for pH-control purposes.

Fig. 1 presents the data in condensed fashion. The scales in this figure are both logarithmic. Curve A

Table I. Spectrographic Analyses of Quartz Samples

Element	Abundance, Pct		
	Lot I	Lot II	Lot III
Al	0.1 to 0.01	0.1 to 0.01	Less than 0.001
Na	Less than 0.001	0.01 to 0.001	Less than 0.001
Mg	0.1 to 0.001	0.01 to 0.001	Less than 0.001
Cu	Less than 0.001	Less than 0.001	Less than 0.001
Fe	Less than 0.001	0.01 to 0.001	Less than 0.001
Ti	Less than 0.001	Less than 0.001	Less than 0.001

^a Repurified after earlier use with Na^{+} .

Table II. Attainment of Equilibrium

Time of Agitation, hr	Final pH	Na ⁺ Concentration, Mols $\times 10^{-3}$ Per Liter	Amount Na ⁺ Adsorbed Mols $\times 10^{-3}$ Per Sq Cm	
			Observed	Corrected to pH 9.70
1	9.6	2.40	1.89	1.98
2	9.7	2.40	1.89	1.89
3	9.8	2.40	1.89	1.90

covers a range of Na^+ concentration of about 100-fold and curve B about 10,000-fold. The overall range in adsorption of Na^+ on quartz is from 10^{-8} to 10^{-2} mol per sq cm, or over 1000-fold. Fig. 1 shows that the adsorption increases as the sodium-ion concentration, but much more slowly. In fact, in most ranges the sodium-ion adsorption varies about as the square root of the sodium-ion concentration in the liquor, or even less rapidly.

Effect of pH: One series of tests was conducted in which the sodium concentration was kept constant while the pH was varied with dilute nitric acid. The results obtained are given in Fig. 2. The amount of sodium adsorbed decreases with increase of hydrogen-ion concentration.

Two additional series of tests were carried out to substantiate the results of Fig. 2. Qualitative support was obtained, although the scatter in these later tests was greater than in the earlier set. At present it seems as if a straight line relationship may exist between the logarithm of the amount of sodium adsorbed and the pH of the solutions. A linear relationship had also been shown to hold between the amount of barium adsorbed onto a quartz surface and the pH of test solutions.⁶

Fig. 2 shows that for a tenfold increase in hydroxyl-ion concentration the sodium ion adsorbed is increased by a factor of 1.5 only, or 50 pct. This correction was applied for the data in order to pre-

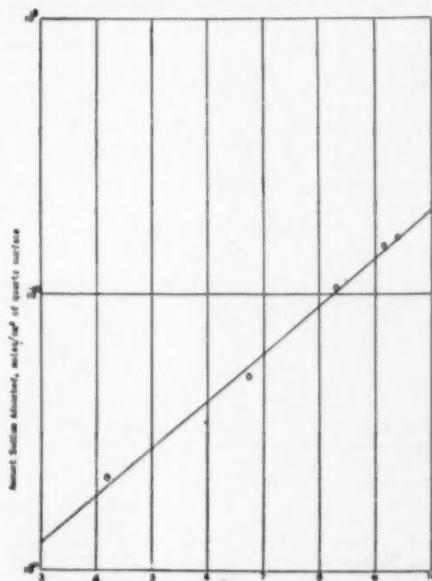


Fig. 2—Effect of pH on adsorption of sodium on quartz.

Table III. Effect of Cation Additions on Adsorption of Sodium on Quartz

Cation Present, Millimoles Per Liter	Final pH	Na ⁺ Concentration, Millimoles Per Liter	Amount Na ⁺ Adsorbed	
			Mg per g of Quartz	Mols x 10 ⁻¹⁰ Per Sq Cm
0.242 Li ⁺	9.5	2.62	0.00761	1.90
0.242 Li ⁺	9.5	2.64	0.00705	1.30
1.21 Li ⁺	9.5	2.64	0.00622	1.00
0.257 Cs ⁺	9.5	2.64	0.00653	1.20
1.33 Cs ⁺	9.5	2.66	0.00464	0.913
				1.12

pare curves A and B of Fig. 1 using pH 10 and pH 6 respectively as the norms.

Effect of the Presence of other Cations: Four tests were run in which varying concentrations of cesium or lithium nitrate were added to the test solutions. The test results are summarized in Table III. This shows that cesium and lithium displace sodium from the surface of quartz and that cesium is more effective than lithium.

Effect of Variation of the Predominant Anion Present: Six tests were conducted in which standard sodium solutions other than sodium nitrate were added. Solutions of sodium chloride, sodium fluoride, and sodium sulphate were added and the adsorption of sodium determined.

The results obtained, which are summarized in Table IV, indicate that the anion present has some effect. More work is needed to evaluate it more than qualitatively.

Reversibility of Adsorption: Three tests were run to verify the exchange between active and inactive sodium at the surface of quartz.

In each test 1 liter of sodium solution was allowed to percolate slowly through a bed containing 12 g of quartz. The time allowed for percolation was approximately 3 hr. The solutions used in the tests were all of the same sodium concentration, but some were made active and others not.

In the first test 1 liter of active solution was percolated through the quartz bed and the activity on the quartz determined. In the second test 1 liter of active solution was followed by 1 liter of inactive solution and the activity remaining on the quartz again determined. In the final test 1 liter of inactive solution, then 1 liter of active solution were passed through the bed and the activity on the quartz determined.

The results obtained from the tests are summarized in Table V. These results indicate that al-

Table V. Reversibility of Adsorption

Solutions Added		Wt of Quartz, g, Retained by 12 g of Quartz	Activity on 12 g of Quartz, cpm ^a	Per cent of Activity Compared to Standard Test on Quartz Sample
Solution 1	Solution 2			
Active	None	0.3877	382	100
Active	Inactive	0.4054	7.2	1.83
Inactive	Active	0.3856	382	90.4

^a Counts per min.

most complete exchange takes place on passage of 1 liter of solution through a 12-g bed in 3 hr. With sufficient time of contact complete reversibility of adsorption of active and inactive sodium appears certain.

Discussion of Results

The present-day concept of adsorption at a solid-liquid interface visualizes the existence of a so-called double layer of ions at the interface.¹ This double layer is thought to be made up of an inner part attached to the surface and an outer diffuse part.² For a quartz-solution interface the ϕ potential is negative (-44 mv according to Freudlich). Likewise, for a fused-silica interface recent accurate measurements by Wood³ give the still higher negative potential of -177 mv. Therefore the double layer may be considered to consist of an inner layer of anions and an outer layer of cations. The cations are loosely held and therefore wander off into the solution imparting a net negative potential to the surface. The diffuse part extends into the solution and is also made up of both cations and anions.

When a quartz particle is placed in pure water, hydroxyl and hydrogen ions are adsorbed onto the surface and into the diffuse layer.⁴ A dynamic equilibrium is established between the ions in the solution and those on the surface. The presence of other ions would alter this equilibrium, the new equilibrium depending upon the nature and concentration of the ions in the solution.

The thickness and concentration of ions in the diffuse part varies with the concentration of the solution. The thickness is equal to the reciprocal of the Debye-Hückel function, K , and can be calculated from the following equation:

$$\delta = 1/K = \sqrt{\frac{1000 D R T}{8 e^2 N^2}} \sqrt{1/c}$$

In this equation δ is the thickness of the diffuse layer in centimeters; D is the dielectric constant, about 80 for water at 25°C; R is the gas constant, 8.314x10⁻³; T is the absolute temperature in degrees Kelvin; e is the charge of the electron, 4.77x10⁻¹⁰ electrostatic units; N is the Avogadro number, 6.02x10²³; and c is the ionic concentration of the solution in gram ions per liter or mols per liter.

The thickness δ does not represent a distance beyond which there is no diffuse layer. Rather, it represents a theoretical thickness which would give exactly the same electrical effect at the interface as actually occurs, if all the ions in the outer layer were maintained at the distance δ from the ions in the inner layer. It would be necessary to select a double layer about 48 in thickness in order to include in it about 98 pct of all the ions in the diffuse layer.

In the experimental results presented here in condensed form and found in detail in the thesis by Laxen,⁵ it is shown that the filtered and centrifuged

Table IV. Effect of Anion Present on Adsorption of Sodium on Quartz^a

Sodium Salt	Actual Final pH	Actual (Na ⁺) Millimoles Per Liter	Actual Na ⁺ Adsorbed	
			Microgram Per g Quartz	Mols x 10 ⁻¹⁰ Per Sq Cm, Corrected to pH 6
NaCl	9.0	0.453	0.371	0.0006
Blank (NaNO ₃)		0.453		0.114
NaCl	5.8	4.84	0.529	0.124
Blank (NaNO ₃)		4.84		0.248
NaF	9.0	0.106	0.266	0.0577
Blank (NaNO ₃)		0.106		0.052
Na ₂ SO ₄	5.8	0.0137	0.089	0.0176
Blank (NaNO ₃)		0.0137		0.013
Na ₂ SO ₄	5.8	0.106	0.212	0.053
Blank (NaNO ₃)		0.106		0.052
Na ₂ SO ₄	5.8	0.0138	0.085	0.0182
Blank (NaNO ₃)		0.0138		0.013

^a Values read from graph of Fig. 1.

solids contain in general about 3 pct moisture by weight. Since the specific surface of the quartz used in this work is about 2000 sq cm per g and since 3 pct moisture may be accepted as an average value of the liquor content of the filter cake, it may be shown that the thickness of liquor film around each mineral particle averages 1600A. From the equation giving 8, the thickness of the diffuse layer at the lowest concentration of sodium, 8.48×10^{-6} mols per liter, would be approximately 1000A. For more concentrated solutions the diffuse layer would be thinner, and for the most concentrated solution it would be about 13A. In each test, therefore, the diffuse layer has been part of the solution retained to a greater or lesser extent by the quartz bed. The adsorbed sodium as measured in our experimental work has, therefore, been that due to the sodium absorbed at the surface of the quartz plus most of the excess sodium in the diffuse layer.

When the suspension of quartz and solution are filtered and centrifuged, it is quite probable that the equilibrium distribution of ions between the solution and the solid surface are disturbed somewhat. This is one phase of the experimental procedure which might well be studied further.

For each 23.4A² of quartz surface, there exists an anionic and a cationic adsorption site.¹³ If one sodium ion is assumed to be adsorbed at each cationic site (or one sodium ion is assumed to be adsorbable in the diffuse layer in apposition to each anionic site

$$\text{on the quartz), a monolayer would require } \frac{1}{23.4 \times 10^{-20}}$$

$$\text{ions per sq cm or } \frac{1}{6.02 \times 10^{23} + 23.4 \times 10^{-20}} = 7.1 \times 10^{-10}$$

g-ions per sq cm. Inspection of Fig. 1 shows that adsorption equal to such a monolayer is obtained only at sodium-ion concentrations over 0.07 M and at a high pH.

If it be assumed that sodium ions in water are hydrated so that the overall diameter of a sodium ion equals the diameter of two water molecules plus that of one anhydrous sodium ion, or about 7.5A, it is clear that a monolayer adsorbed at the quartz will contain fewer ions than 7.1×10^{-10} g-ions per sq cm, since the ion size is too large to be accommodated at each site.

On the value for the diameter of the hydrated sodium ion obtained by Remy¹⁴ and used recently by Nachod and Wood,¹⁵ that is 16A, each sodium ion would occupy approximately eight adsorption sites on the quartz surface. A surface concentration of 7.9×10^{-10} g-ions of sodium per sq cm corresponds to a completed monolayer of sodium ions on the basis of the above diameter for the hydrated sodium ion. Even on the basis of Remy's liberal evaluation of the size of the hydrated sodium ion, it is clear that a monolayer would be obtained only under the circumstance of high pH or high concentration.

Neither the Freundlich¹⁶ nor the Langmuir¹⁷ adsorption isotherm can be applied to fit the adsorption isotherms in Fig. 1 over the entire range. A Freundlich equation can, however, be applied to the straight line portion of curve A giving the adsorption from solutions at very low sodium concentrations.

The results obtained on the addition of other cations such as cesium and lithium to sodium solutions confirm those obtained by previous investigators on the relative magnitude of adsorption of ions onto

clays and other materials.^{1, 18, 19} Cesium displaced more sodium from the quartz than an equivalent concentration of lithium, agreeing with their positions in the so-called *Lyotropic Series* for alkali metals, $\text{Cs}^+ > \text{Rb}^+ > \text{K}^+ > \text{Na}^+ > \text{Li}^+$. This series has been used to represent the order of magnitude of adsorption of the alkali metals. The adsorption affinity increases with decreasing hydrated ionic radius.

The amount of sodium adsorbed was shown to be also dependent on the anion present. With the four anions tested, the most sodium was adsorbed in the presence of fluoride ions and the order of decreasing sodium adsorption was as follows:



The authors hope that this contribution to the accumulation of data regarding the adsorption of ions onto minerals will result in a better understanding of the nature of solid-liquid interfaces so essential in the development of flotation theory and practice.

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The Effect of Certain Starches on Quartz and Hematite Suspensions

by Strathmore R. B. Cooke, Norman F. Schulz,
and Emert W. Lindroos

DURING the course of an investigation of the effects of various starch products on hematite and quartz in regard to their separation by flotation, it was found that whereas most starches flocculated suspensions of hematite in water, they did not flocculate similar suspensions of quartz. However, a derivative of whole corn starch containing approximately one tenth aminoethyl group ($-\text{CH}_2\text{CH}_2\text{NH}_2$) per glucose unit proved to be an exception. This aminoethyl starch was a very good flocculant for both hematite and quartz, and also possessed the property of depressing both minerals in cationic flotation tests. In view of the widespread use of starch as a flocculating agent of solids in tailing water, pulps, and for coal slimes, ore and various other purposes in sulphide and nonsulphide flotation, attention is called to the effective surface activity of aminoethyl starch in flocculating suspensions of the two minerals investigated.

Test Materials

The starch products employed included Globe Pearl starch No. 144 and fresh aminoethyl starch, both supplied by the Corn Products Refining Co. Dr. A. L. Elder* has kindly furnished a description

* Director of Research, Corn Products Refining Co., Argo, Ill.

of the preparation of the aminoethyl starch: "Three hundred and sixty grams of powdered unmodified corn starch was slurried in 3 liters of water and stirred during gelatinization. Eighty-six grams of ethylenimine was added slowly during reflux which was continued for 4 hr. The yellow solution set to a gel upon cooling. This was broken up and neutralized with HCl. The thick paste was dried on hot rolls. Adsorbed polyethylenimine and salts were removed from the yellowish products by washing first with acidified aqueous '60 per cent' alcohol. The white product contained nitrogen corresponding to about one aminoethoxy group per ten glucose residues." Only laboratory samples of this starch derivative have been prepared.

The starch reagents for use in flocculation, flotation, and adsorption tests were made up by dispersing the appropriate quantities of air-dry starch in cold water, adding boiling water, and heating for 30 min at 120°C under pressure. When used in adsorption tests, the starch solutions first were cleared of insoluble matter by centrifugation.

The minerals used in the various tests are listed in Table I. Their specific surfaces were determined by the air permeability method, which gave results reproducible to within plus or minus 3 pct. Surface areas obtained by krypton adsorption were greater than the air permeability values by a factor of 2.0 for quartz and 62.4 for hematite.

Starch Adsorption on Mineral Surfaces

Starch adsorption data were obtained by agitating for 1 hr measured volumes of neutral starch solutions of known concentrations with weighed quantities of finely divided mineral of measured specific surface. The mineral then was separated from the pulp liquor by centrifugation and the residual starch content determined by chemical analysis. The analytical procedure consisted of oxidizing the starch with an excess of dichromate in acid medium at elevated temperature and titrating the excess dichromate by the ferrous ammonium sulphate-potassium permanganate method. Analytical results were reproducible to within less than 1 pct.

Adsorption data obtained in unbuffered solutions near the neutral point are plotted in Fig. 1. The adsorption on either mineral was far greater for the aminoethyl starch than for the Pearl starch.

Flocculation

The degree of flocculation was determined for a given pulp by measuring the time required for the supernatant liquid to reach a certain degree of clarity. This was accomplished by passing a standard light beam through the pulp, contained in a glass settling tube, and measuring the time required after agitation ceased for the intensity of the transmitted beam to reach a predetermined value. Starch reagent was added to each pulp in small uniform increments, and the settling time was determined after each such addition. Increase in pulp liquor volume due to the added starch reagent was ignored in these tests. Pulps were maintained at or near neutrality.

S. R. B. COOKE, Member AIME, Professor of Metallurgy and Mineral Dressing, School of Mines; N. F. SCHULZ, Corn Products Refining Co. Research Fellow, School of Mines; and E. W. LINDROOS, Graduate Student, are with the University of Minnesota, Minneapolis.

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Plots of the settling time against starch content, see Fig. 2, show that the two starch products produced similar results in the flocculation of hematite ore. Quartz suspensions were not flocculated by the Pearl starch but were well flocculated by the aminoethyl starch derivative.

Optimum flocculation effects were observed at starch concentrations producing considerably less than a saturated adsorption coating on hematite ore.

Table I. Characteristics of the Minerals Tested

Mineral	Density, G per Cu	Screen Mesh	Analy- sis, Pct	Specific Surface, Cm ² per G	Compo- sition, Pct
Quartz: Ottawa sand, leached in hot HCl, ground in Abbe pebble mill.	2.65	65/200 -200	12.0 86.0	2800	SiO ₂
Hematite Ore: Hand-picked, high grade ore, ground in sample pulverizer.	4.5	65/200 -200	34.7 65.3	2060	62.4 Fe
Wash Ore Tails:					27.5 Fe
From W. Mesabi Range, Minn., ground and de-slimed.		+65 100/150 150/200 200/270 270/350 350/450 450/550 550/650 650/750 750/850 850/950 950/1050 1050/1150 1150/1250 1250/1350 1350/1450 1450/1550 1550/1650 1650/1750 1750/1850 1850/1950 1950/2050 2050/2150 2150/2250 2250/2350 2350/2450 2450/2550 2550/2650 2650/2750 2750/2850 2850/2950 2950/3050 3050/3150 3150/3250 3250/3350 3350/3450 3450/3550 3550/3650 3650/3750 3750/3850 3850/3950 3950/4050 4050/4150 4150/4250 4250/4350 4350/4450 4450/4550 4550/4650 4650/4750 4750/4850 4850/4950 4950/5050 5050/5150 5150/5250 5250/5350 5350/5450 5450/5550 5550/5650 5650/5750 5750/5850 5850/5950 5950/6050 6050/6150 6150/6250 6250/6350 6350/6450 6450/6550 6550/6650 6650/6750 6750/6850 6850/6950 6950/7050 7050/7150 7150/7250 7250/7350 7350/7450 7450/7550 7550/7650 7650/7750 7750/7850 7850/7950 7950/8050 8050/8150 8150/8250 8250/8350 8350/8450 8450/8550 8550/8650 8650/8750 8750/8850 8850/8950 8950/9050 9050/9150 9150/9250 9250/9350 9350/9450 9450/9550 9550/9650 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Geologic Setting of the Copper-Nickel Prospect

In the Duluth Gabbro Near Ely, Minnesota

by G. M. Schwartz and D. M. Davidson

THE Duluth gabbro outcrops containing sulphides of copper, nickel, and iron are located on both sides of State Highway No. 1 an airline distance of 8.5 miles southeast of Ely in northeastern Minnesota. The region of known sulphide occurrences includes parts of sections 5, T. 61 N., R. 11 W., and parts of sections 25, 26, 32, 33, and 34, T. 62 N., R. 11 W. These sections, given in Fig. 1, are all in Lake County, Minnesota. Part of the area, which lies entirely within the Superior National Forest, is shown on the topographic map of the Ely quadrangle.

The original discovery was made in 1948 when a small pit was opened in weathered gabbro rubble for use on a forest access road. A shear zone had caused unusual decomposition in this glaciated area, and the resulting copper stain was noted by Fred S. Childers, Sr., an Ely prospector, who began searching the outcrops along the base of the intrusive. He was joined in further exploration by Roger V. Whiteside of Duluth. In the summer of 1951 a small diamond drill was moved into the area and a hole 188 ft deep was drilled, passing through 11 ft of glacial drift into sulphide-bearing gabbro. This paper is a preliminary report on the geology of the newly discovered ore.

The Duluth gabbro is one of the largest known basic intrusives and may be defined as a lopolith.¹ It extends northeastward from the city of Duluth as a great crescent-shaped mass that intersects the shore of Lake Superior again near Hovland, 130 miles to the northeast, see Fig. 2. The distance around the outside of the crescent is nearly 170 miles. The form of the intrusive is simple at Duluth where it ends abruptly north of the St. Louis River; at the east end, however, the gabbro splits into two elongated, sill-like masses separated mainly by lava flows and characterized by minor irregularities. The outcrop reaches a maximum width in the central part where it is about 30 miles across, and a maximum thickness of about 50,000 ft. It may be significant that the sulphides occur at the base of the thickest part.

The lopolith has segregated into rock types ranging from peridotite to granite. The most abundant types are olivine gabbro, gabbro, troctolite, anorthosite, and granite. Of lesser importance quantitatively are peridotite, norite, pyroxenite, magnetite gabbro, and titaniferous magnetite. Grout estimates that two-thirds of the gabbro at Duluth is olivine gabbro. Variations in the percentages of plagioclase, augite, olivine, and magnetite-ilmenite constitute the only essential differences found among the basic rock types. The predominant mineral is

plagioclase, mainly labradorite. Plagioclase and olivine seem to have crystallized early, and the olivine rich rocks, usually troctolite, are found in the lower part. Segregations of titaniferous magnetite are abundant near the base of the gabbro along the eastern part and also occur far above the base. These have recently been described in detail by Grout.² Near the top, segregation has produced a gradation to granite, or "red rock," as it is known locally. This consists of quartz, red feldspar, and hornblende. The red rock forms a zone with a maximum width of nearly 5 miles but is quantitatively unimportant from Duluth northward for 35 miles. In Cook county, where the gabbro splits, each of the two sill-like masses has a red rock top somewhat thicker in proportion to the gabbro below than in the main central mass.

The intrusive ranges from coarse to medium in grain size and from granitoid to diabasic in texture. Throughout much of the Duluth gabbro in Minnesota banding and foliation are well developed, as Grout has emphasized.³ The bands are mainly a result of variation in the percentage of minerals, as in troctolite with alternating bands high in olivine and in plagioclase. A few bands may consist largely of one mineral, as is true of some segregations of magnetite. Many of the banded rocks show a clearly developed parallelism of platy plagioclase crystals, and both banding and foliation are believed to conform to the floor of the lopolith.

Throughout its extent in Minnesota the Duluth gabbro dips east and south toward Lake Superior. It is generally believed to extend beneath Lake Superior and is found as a smaller mass exposed along the north side of the Gogebic district in Wisconsin and Michigan. The dip at and near the base ranges along most of its length from 20 to 40°, but at places the internal banding dips even more steeply. The dip of the upper part is much less, and if it is assumed that the flows along the north shore of Lake Superior are a dependable indication, it does not exceed 15°.

The formations shown in Table I which are intruded by the gabbro range from Keewatin to Middle Keweenawan in age. They present a significant picture. At the top, the gabbro and its accompanying

G. M. SCHWARTZ, Member AIME, is Professor of Geology and Director, Minnesota Geological Survey, University of Minnesota, and D. M. DAVIDSON, Member AIME, is Vice President and Chief Geologist, E. J. Longyear Co., Minneapolis.

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red rock facies intrude Keweenawan lava flows and possibly some diabase sills throughout its length. It appears to be only moderately discordant. The base of the lopolith, however, is very different, as gabbro is in contact with formations ranging from Keewatin to Middle Keweenawan in age. A significant point is that the base at both ends lies at about the same horizon near the base of the Keweenawan flows. Grout¹ suggests that the magma must have spread for the most part along an unconformity at the base of the Lower Keweenawan formation, which is of Puckwunge sandstone.

The rocks at the contact with gabbro are recrystallized to hornfels almost regardless of the mineralogical character of the original rocks.²⁻⁴ The contact rock and also numerous inclusions in the gabbro have a sugary texture with grains averaging about 5 mm in diam. Where the intruded rock is basic in character the hornfels may closely resemble the gabbro except that they are always coarser-grained.

As might be expected for such a large area, the amount of gabbro exposed varies greatly from place to place. At and near Duluth the exposures are abundant and are well shown on maps included in a recent report.⁵ North of Duluth, where the lopolith trends away from Lake Superior, glacial deposits are thicker, and therefore outcrops become scant and are altogether lacking over a large area south of the Mesabi range. From the Mesabi range eastward, outcrops are common and sometimes abundant near the base, but to the south glacial moraines cover large areas. Eastward in Cook County outcrops are fairly general. Considerable detail will be shown on maps to accompany a report on that county being prepared by Dr. Frank F. Grout.

The Copper-Nickel Rocks

As previously noted, the sulphide-bearing gabbro has been found in scattered outcrops over a length of 5 miles. This, however, is not the first discovery of sulphides in the Duluth gabbro. Sporadic occurrences have been noted in the past by many geologists, and a few have been described,⁶⁻⁸ but none of these were extensive enough to receive serious consideration as possible economic deposits.

Although much geological work has been done on the Duluth gabbro, the outcrops have never been completely mapped because large areas occur in heavily brush-covered wildland. No detailed work has been done in the vicinity of the sulphide prospects; available information is shown on Fig. 1.

Petrography: The sulphide-bearing rock ranges from medium to very coarse-grained gabbro. Speci-

mens from different outcrops over a length of 5 miles show considerable variation in grain size and in mineral composition. The fine to medium-grained gabbro is a medium dark grey, and the coarser-grained varieties are a medium gray color. The coarsest-grained rock is practically an anorthositic and contains plagioclase grains up to an inch in length. Previous studies of the gabbro where it is well exposed have shown that the different varieties usually make up bands of varying thickness. The bands extend some distance along the strike of the gabbro mass, although some are lenticular and cannot be traced far.

Examination of thin sections and polished surfaces of the gabbro indicates that it contains the following minerals in decreasing order of abundance: labradorite, olivine, augite and hypersthene, magnetite-ilmenite, biotite, chalcopyrite, cubanite, pyrrhotite, pentlandite, apatite, and bornite.

Thin sections of most known sulphide-bearing outcrops as well as samples from the diamond drill hole at a depth of 47 and 87 ft have been examined. The writers are indebted to Dr. Frank F. Grout for checking the interpretations. The thin sections represent different facies of the gabbro, no two resembling each other very closely. The range is from feldspathic gabbro to troctolite; the approximate percentages of the essential minerals are shown in the following tabulation of thin sections.

Plagioclase	75	75	65	65	65	65	65	35	30
Pyroxene	8	10	—	25	15	30	5	25	—
Olivine	15	3	30	5	15	10	35	15	—

None of the sulphide-bearing rocks had sufficient orthorhombic pyroxene to warrant use of the term "norite," but elsewhere norite has been observed, particularly by Nebel.⁹

The sulphides occur in all of the silicates but are most abundant in plagioclase. A characteristic texture is disseminated sulphide in plagioclase adjacent to larger areas of sulphide. Many inclusions are somewhat elongated and arranged parallel to the twinning bands of the feldspar, see Fig. 3. There is no alteration of the feldspar associated with the inclusions, so that the nearly simultaneous formation of feldspar and sulphide is indicated. The areas of sulphides are commonly interstitial to the silicates, especially feldspar. The dominant pyroxene is augite, but enstatite is almost equally abundant in one section, and diopside and hypersthene were noted in a complex intergrowth. A small amount of biotite characteristically occurs at or near sulphide areas but rarely elsewhere, see Fig. 4. The biotite

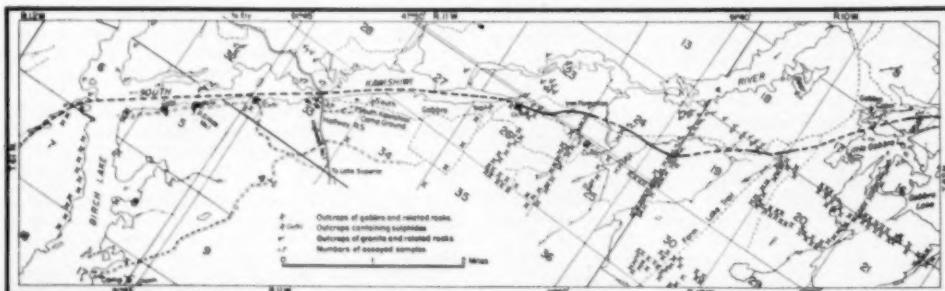


Fig. 1—Area of known copper-nickel occurrences, Lake County, Minnesota.

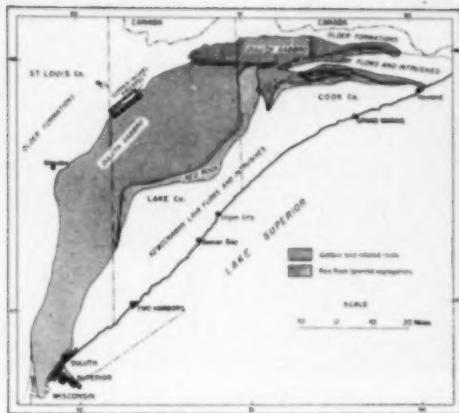


Fig. 2—Map showing the outline of the Duluth gabbro and its relation to other formations.

replaces other silicates and is possibly deuteritic. Some sulphide may also be classified as deuteritic. Most grains of olivine are not altered, but some show attack at the edges by complex veinlets consisting of antigorite, chrysotile, and iddingsite, either separate or intermixed. Some olivine is cut by irregular stringers of magnetite with narrow borders of serpentine. There is a small amount of alteration of pyroxene to chlorite and in a few places to carbonate. One thin section shows graphic intergrowths of sulphides in augite, see Fig. 5. The augite in the intergrowth is conspicuously finer-grained than surrounding grains of pyroxene, some of which are in contact with the intergrowth. The texture suggests simultaneous crystallization of pyroxene and sulphide.

Chalcopyrite is the most abundant sulphide in most specimens, but cubanite may predominate in some aggregates. Where the two minerals are together they form the familiar lath-like crystallographic intergrowths that result from exsolution. Pentlandite and pyrrhotite occur as irregular grains interlocked with chalcopyrite and cubanite. A very small amount of bornite occurs with the other sulphides.

Table I. Formations Intruded by the Duluth Gabbro Range

Age	Formation	Rock
Pleistocene	Glacial drift	Moraines, glacial lake deposits, and outwash
Keweenawan	Fond du Lac beds	Sandstone and shale
	Duluth gabbro, Beaver Gabbro, Bay complex, Logan sill	Dolomite, granite, diabase
	Keweenaw Point volcanics	Basic and acidic lava flows, interbedded arkose, sandstone and tuffs
	Puckwunge formation	Sandstone, conglomerate
Algoman	Giant's Range and other masses	Granite
Knife Lake time	Knife Lake group	Slate, graywacke, conglomerate and conglomerate
Laurentian	Saganaga mass	Granite
Keewatin	Soudan iron-bearing formation	Jasper and hematite
	Ely greenstone	Metamorphosed volcanics and intrusives

phides in some polished sections. The small bornite areas almost invariably contain excellent exsolution intergrowths of chalcopyrite. More common is bornite along the pseudo-tetrahedral, or tetragonal bisphenoidal, planes of chalcopyrite.

Some polished sections reveal a few tiny veinlets of sulphide that are later in origin than the silicates. These, however, do not contradict the fact that sulphide is intergrown with plagioclase without any evidence of having been introduced after crystallization of the plagioclase. It seems probable that these veinlets, like the sulphide with biotite, are deuteritic.

Magnetite-ilmenite is abundant in some specimens. The two minerals can be distinguished when a very high polish is obtained. Ilmenite occurs as an intergrowth in magnetite and also in the form of grains.

Copper-nickel content: Results of systematic sampling are available only from the vertical diamond drill hole drilled by Messrs. Fred S. Childers, Sr., and Roger V. Whiteside, who have generously given permission for the results to be quoted. Bedrock was reached at 11 ft, core was split, and one-half was crushed for assay samples of 5-ft lengths down to 115 ft. For a core length of 104 ft the average assay is 0.36 pct copper and 0.13 pct nickel. The highest grade 5-ft section from 21 to 26 ft assayed 1.02 pct copper and 0.21 pct nickel. The sludge from 115 to 124 ft, where core recovery was poor, assayed 0.21 pct copper and 0.10 pct nickel. Below 124 ft the sulphide content diminished rapidly and no more was found to the bottom of the hole at 188 ft. The rock from 124 to 188 ft is rather uniform, dark gray, coarse-grained feldspathic gabbro. An unnumbered hole was originally started about 50 ft south of No. 1 hole but yielded little sulphide and was discontinued at 20 ft.

Various samples from outcrops of the sulphide-bearing rock have been assayed and the results made available by the Minnesota Geological Survey, U. S. Bureau of Mines, E. J. Longyear Co., and Messrs. Childers and Whiteside. These show about the same range in copper and nickel content as the diamond drill hole noted above. Results of samples collected by the Minnesota Geological Survey at the seven locations shown on Fig. 1 are given in Table II. A sample collected at Location No. 1 by E. P. Chapman of the U. S. Bureau of Mines and assayed independently revealed 1.06 pct copper and 0.38 pct



Fig. 3—Copper-nickel sulphides (black) in gabbro. The silicate is mainly plagioclase and the disseminated sulphide is oriented parallel to the twin bonds. Thin section, plain light. X50.

Table II. Surface Sampling of Cu-Ni Content in the Duluth Gabbro

Location	Cu Pct	Ni Pct
1	1.12	0.38
2	0.38	0.10
3	0.70	0.14
4	0.72	0.14
5	0.27	0.09
6	0.39	0.07
7	0.33	0.10

nickel. Inasmuch as the samples were collected after several blasts in the outcrop, this is satisfactory confirmation. A second sample collected by Mr. Chapman about 3 miles to the northeast, near the east end of the known sulphide-bearing outcrops, contained 1.16 pct copper and 0.21 pct nickel.

A total of 29 grab and chip samples from about 12 outcrops averaged 0.59 pct copper and 0.17 pct nickel. Although these were not systematic and were taken by several different men, they may be accepted as indicating the copper and nickel content in outcrops along the known belt of sulphide occurrences.

Summary

The significant features of the occurrence of copper and nickel sulphides near the base of the gabbro may be briefly listed as follows:

1.—The sulphides are well disseminated throughout over 100 ft of rock and appear to be primary constituents.

2.—Widely scattered outcrops extend to a length of more than 5 miles not far from the base of the Duluth gabbro and approximately parallel to it.

3.—The Duluth lopolith is known to be well banded or layered throughout much of its extent, and it is a reasonable inference that the distribution of the sulphides is related to this layering near the base of the widest part of the intrusive.

4.—The sulphide minerals are those characteristic of copper-nickel deposits elsewhere.

5.—The known extent of rock that will average 1 pct or more of combined copper and nickel is strictly limited, and the outcrops are too far apart to be considered with certainty as being connected by sulphide-bearing rock. The structure of the intrusive, however, indicates a possibility that the sulphides are continuous.

6.—The location of the prospect is favorable. It is crossed by a paved highway and is about 8 miles from a railroad. As indicated by scattered outcrops, the glacial drift is probably thin over much of the area.

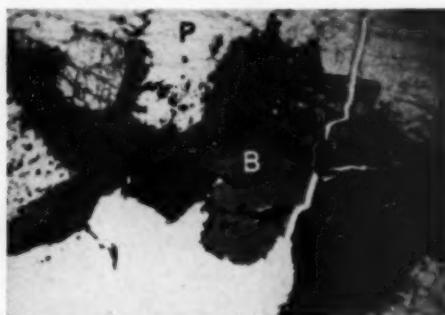


Fig. 4.—Sulphides (black) associated with biotite (B) which is probably a deuteric replacement of olivine and plagioclase (P). The white at lower left is balsam. Thin section, plain light. X30.

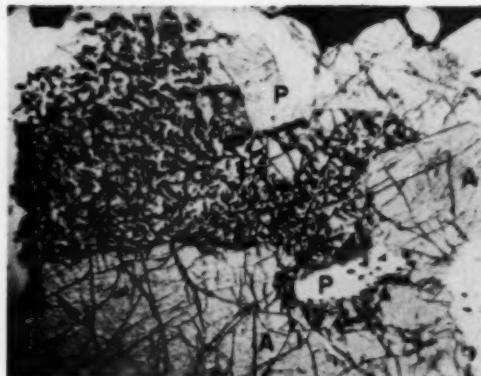


Fig. 5.—Sulphides (black) intergrown in augite (A) and plagioclase (P). Thin section, plain light. X25.

7.—At present there are no dependable indications of the presence or absence of massive sulphides such as exist in the Sudbury district, but exploration seems warranted because of the structure of the Duluth gabbro, its immense size and large degree of segregation. Strong evidence of the syngentic origin of the sulphides and the considerable length over which they occur also indicate that there is an excellent geological probability of finding a commercial deposit.

These facts, when compared with general knowledge of intrusives of the Duluth gabbro type, suggest that the place to search for extensions of the deposit or for similar deposits is near the base of the gabbro. It is possible that the base near the thickest part of the intrusive is more favorable than the thinner ends near Duluth and in eastern Cook County. In any event there are areas 25 or 30 miles long on each side of the deposit that should be given careful examination. Over much of this length there are scattered and sometimes abundant outcrops of gabbro. South of the Mesabi range, however, there is a distance of over 30 miles where not a single outcrop is known near the base of the Duluth gabbro.

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Determination of the Temperature and Pressure of Formation of Minerals by the Decrepitometric Method

by F. Gordon Smith

ALTHOUGH several geological indicators of the critical type are known, including quartz inversions and decomposition of hydrous minerals such as serpentine, there are very few of the general type. Solid solutions are excepted, but the limitations of use are very restricted and interpretations are sometimes ambiguous. General methods for determining temperature and pressure conditions during the crystallization of minerals would have considerable scientific and economic value.

It is not the purpose of this paper to discuss the various methods of geological thermometry and barometry, but to present one general method, applicable to all minerals, and to describe what progress has been made in the methods of measurement. The general method, in brief, is a study of the stress conditions in and around various types of foreign inclusions which are trapped in minerals during growth.

The method depends upon the fact that any homogeneous gas, liquid, or solid will in general have coefficients of thermal expansion and volume compressibility different from those of any given mineral. Therefore stress must develop in and around all types of inclusions in minerals if the temperature or the pressure, or both, are changed from the conditions which prevailed during the growth of the mineral. The methods of measurement consist of determinations of the temperature-pressure conditions of fit of the inclusions in the host mineral.

The types of inclusions in minerals are: 1—gas, or liquid plus vapor, when observed at room temperature, due to crystallization under pneumatolytic conditions; 2—liquid, or liquid plus vapor when observed at room temperature, due to crystallization under hydrothermal conditions; 3—glassy solid, or devitrified glass, due to crystallization under magmatic or high temperature metamorphic conditions, in a siliceous liquid; and 4—crystals, due to overgrowth of other minerals crystallizing simultaneously or of other minerals which crystallized previously.

A survey of the literature shows that much valuable earlier work on inclusions, especially that car-

ried out in England in the last century, has dropped out of current knowledge. The following is a brief summary of the significant contributions to the problem up to the present day.

Davy in 1822 asserted that fluid inclusions in minerals consist of an aqueous solution of salts and a gas bubble, the whole being either at lower or higher pressure than atmospheric.¹

At intervals from 1823 to 1862, Brewster contributed information concerning other types of inclusion consisting of 1—aqueous solution, a much more expandible liquid, and a gas; 2—aqueous solution, salt crystals, and a gas; and 3—the very expandible liquid and a gas. The very expandible liquid fills the gas space between 20° and 30°C. Compression strain effects were seen around inclusions in diamond, topaz, and other minerals.^{2,4}

Sorby in 1858 and 1869 further advanced the study begun by Davy, stating that fluid inclusions represent a sample of the mother liquor of crystallization and that the degree of filling of aqueous inclusions at room temperature defines the temperature-pressure relations during formation of the host. The degree of filling may be measured by determining the minimum temperature of filling of the inclusion by the liquid phase. The very expandible liquid in some fluid inclusions is liquid carbon dioxide. The temperature at which salt crystals in fluid inclusions completely dissolve in the fluid is the minimum temperature of formation. Inclusions of glass or devitrified glass indicate crystallization from a melt. Inclusions of crystals in minerals are often centers of strain, which may be seen by optical effects or by radial tension cracks. Sorby realized that an analysis of stress-strain relations about inclusions could be used to provide precise data on the temperature of crystallization, but the matter was never pursued.^{5,6}

Hartley (1876, 1877),^{7,8} Hawes (1881),⁹ Wright (1881),¹⁰ Johnsen (1920),¹¹ and Holden (1925)¹²

F. GORDON SMITH is Professor of Geology, University of Toronto. Discussion on this paper, TP 33381, may be sent to AIME (2 copies) before Aug. 31, 1952. Manuscript, April 9, 1951. St. Louis Meeting, February 1951.

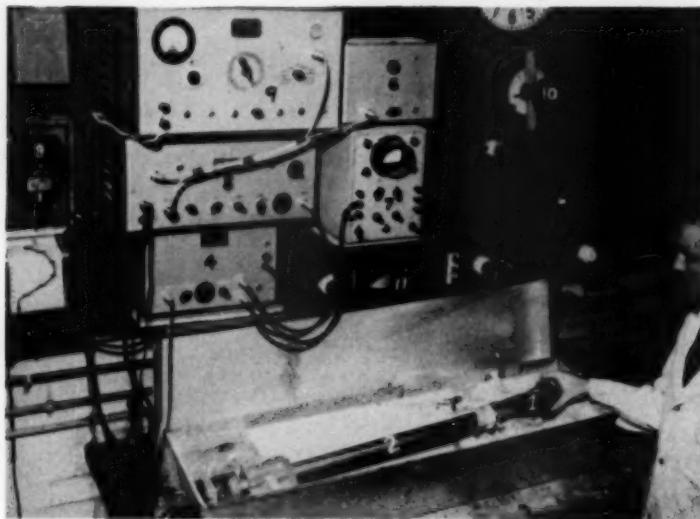


Fig. 1—Decrepitation apparatus. 1. Heating block. 2. Sound conducting tube. 3. Crystal microphone. 4. Two-stage preamplifier. 5. Ratemeter. 6. Neon flash lamp to indicate ratemeter functioning. 7. Oscilloscope. 8. Recording milli-ammeter. 9. Temperature fiducial marker. 10. Variac to control temperature of furnace, which encloses heating block. 11. Cold junction of thermocouple, the hot junction of which is in the heating block.

confirmed the presence of liquid carbon dioxide in many minerals, and in the years between 1901 and 1941 Königberger,¹ Lindgren and Whitehead,² Buerger,³ Newhouse,⁴ and Faber⁵ established beyond question the presence of salt concentrations, of the order of 10 to 20 pct, in the liquid of fluid inclusions. Such high salt concentrations eliminate certain theories of ore deposition.

Ingerson in 1947 reviewed the heating stage method of measuring the temperature of filling of fluid inclusions and produced charts showing the deposition temperature and the deposition pressure.⁶ These charts were modified in 1950 by Kennedy,^{7,8} who restudied the pressure-volume-temperature relations of water.

In recent years H. S. Scott,⁹ F. Gordon Smith,^{10,11} and P. A. Peach¹² have found that the temperature of filling of fluid inclusions can be detected by recording the beginning of decrepitation during heating.

Two-Phase Fluid Inclusions

The minimum temperature of filling of two-phase fluid inclusions by the liquid phase is the minimum temperature of deposition of the host, and the vapor pressure at that temperature is the minimum pressure of deposition. Both values are subject to a small correction because of the thermal expansion and compressibility of the host, but Ingerson⁶ has shown that this correction can be neglected.

In general, the temperature-pressure relations within fluid inclusions above the temperature of filling are not known, because 1—the composition of the fluid is not known in each case, and 2—no data are available on the solutions which have geological importance in this respect, i.e., aqueous solutions of salts and carbon dioxide. However, it is assumed as a first approximation that the temperature-pressure relations on the liquid side of the

vapor pressure curve are the same as for water, these data being known with some exactness. Consequently, the temperature of filling defines the approximate temperature-pressure relations during deposition of the host.

Determinations of temperature of filling may be made by heating while observing under the microscope. The newer method is to heat small fragments and record the temperature at which the rate of decrepitation increases abruptly. This method was developed at the University of Toronto in three main stages. The first technique consisted of heating the powdered mineral while listening with a stethoscope arrangements.¹³ A modification of this technique was microphonic detection and amplification before the earphones. The second change was incorporation of an electronic calculator instead of the human brain to determine the discontinuity of rate of decrepitation.^{14,15} Several different types of heating blocks were designed and discarded for various reasons. The present design, consisting of a cylinder of inconel with a flattened termination to hold the sample, is satisfactory. This allows good sound coupling to the microphone, sound insulation from outside, and rapid cooling after each run. At this stage, temperature fiducial marks were made by a recorder watching a temperature indicator. This was replaced by an electronic temperature fiducial marker which puts 20°C pips on the record. In this way the heating rate and the decrepitation rate are recorded simultaneously. The circuit and other details of the apparatus are now being prepared for publication. The apparatus is shown in Fig. 1.

The calibration of the apparatus is based on an empirical method. A mineral which gives a sharply defined beginning of decrepitation is heated at several different rates, and the recorded temperatures

of beginning are plotted against the heating rate and projected to zero rate of heating. Some of the same preparation is preheated to a temperature in excess of that at the start of decrepitation and the sequence of runs is repeated with this material. By selection of different specimens, the entire working range of temperature and heating rate is covered, for one grain size of one mineral. This has been determined for quartz, $-40+80$ mesh, as a standard, see Fig. 2.

As a control over interpretation of decrepigraphs, it is current practice to observe the degree of filling of two-phase inclusions in polished thin sections of transparent minerals and to estimate the approximate temperature of filling. A chart has been prepared to aid in this estimation, see Fig. 3, when it is determined that the liquid phase is aqueous. The estimated temperature of filling and the decrepitation temperature generally agree within 50°C , in the case of both primary and secondary inclusions. Several hundred determinations of this kind, on 16 different mineral species, have shown that the measured decrepitation is due to the filling of the fluid inclusions, and that there is probably no significant overshoot correction.^{11,12}

Three-Phase Fluid Inclusions

Some attempts have been made in the past to use three-phase fluid inclusions as thermometers and barometers (Johnsen, 1920, and Holden, 1925) but there are many uncertainties. The method depends upon finding, in the one mineral, inclusions of liquid carbon dioxide and gas and also of water and gas and then determining the temperature and pressure, by calculation, from the respective degrees of filling. This method has merits if it can be made quantitative.

It appears to be fairly common, in so-called high temperature minerals, that the three-phase inclusions have a variable water-carbon dioxide ratio, as if the two were immiscible at the time of deposition. Therefore, while most of the inclusions are of three phases, some are essentially of the two types of two phases, i.e., water and vapor and carbon dioxide and vapor. The unknown factors are the mutual solubilities of fluid water and carbon dioxide as functions of temperature and pressure. Until this system is studied under geologically important conditions, the method cannot be used, but it is a fertile field for investigation.

Saline Inclusions

Two-phase inclusions frequently contain crystals of various salts. Generally these are isotropic cubes, probably of sodium chloride, but sometimes they are elongated anisotropic crystals, possibly gypsum. In any case, they appear to have been deposited from the trapped fluid during cooling, because the ratio of salt crystal to fluid is visibly constant, independent of size of inclusion. On warming, the cubic crystals dissolve in the fluid, and the minimum temperature of disappearance is the minimum temperature of deposition.

In most cases, the salts dissolve in the liquid phase before it fills the inclusion. Occasionally they remain, and the temperature of disappearance provides new data. The salt disappearance temperature and the bubble disappearance temperature taken together give a minimum pressure of deposition.

This method has not been used very much since it was described by Sorby in 1858.¹³ Lindgren and

Whitehead used it in one case,¹⁴ but the calculation method was challenged by Bowen some 14 years later.¹⁵

In general the method is not very useful, since only temperature and pressure minima are determined.

Glass Inclusions

A very interesting type of inclusion described by Sorby¹⁶ could be used as an exact thermometer. The inclusions are of glass and/or devitrified glass in minerals which crystallized from siliceous melts. Such inclusions have a multitude of gas vacuoles within the glass or between the minute crystals. The method of measurement would consist of observing devitrified glass inclusions, and determining the temperature at which they become one phase.

Since glasses in general have a greater coefficient of thermal expansion than the corresponding denser crystals, it will be apparent that if the mineral is heated above the temperature at which the glass inclusion is one phase, the pressure on the glass should abruptly increase, thus causing decrepitation of the mineral.

The effect of pressure at the time of deposition has not been calculated; this requires a knowledge of the thermal expansion and compressibility of the glass as well as the host mineral. However, a first approximation calculation shows that the pressure correction probably is positive. That is, if the glass fits in the space of the inclusion at a determinable temperature at room pressure, it would fit in the space at a somewhat higher temperature at a higher pressure.

Glass and devitrified glass inclusions were seen by Sorby¹⁷ in feldspar and augite in pitchstone and greenstone, and in leucite and augite in basalt.

The study of inclusions offers a method of discriminating between minerals which crystallized from a siliceous melt and those which crystallized from a hydrothermal solution. In the case of certain pegmatites this is now a question for debate, but the types of inclusions may be used in settling the problem.

Crystal Inclusions

During growth, crystals frequently include others which either grew on the growing faces and were covered or were enveloped from the matrix by a growing face. The first type is usually oriented, the second, unoriented. When the temperature and pressure fall to those at the surface of the earth, a misfit of the crystal inclusions develops, and this provides not only a very interesting type of thermometer but also a barometer.

Neglecting the effect of pressure, the temperature, volume, and stress relations in inclusions can be treated very simply, see Fig. 4. Two types of inclusions may be imagined, one type with a thermal expansion greater, and the other less than that of the host. The misfit during cooling to surface conditions develops tension and compression effects, respectively. Brewster¹⁸ and Sorby¹⁹ noted effects arising from compression in diamonds and other minerals. Possibly some of the cracking of minerals, even those in vugs, may be due to this effect.

The effect of heating a mineral with the two types of crystal inclusions is to relieve the stress in and around both types, up to the temperature of formation. Above this temperature, both compression and tension effects begin again, in opposite sense, and the compression type may cause decrepitation.

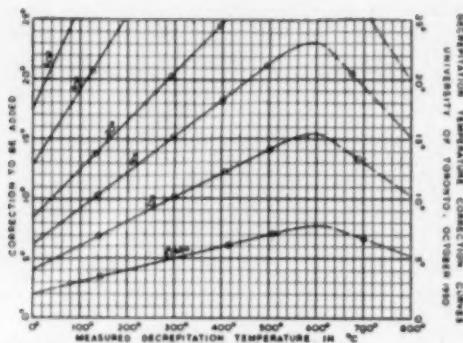


Fig. 2—Heating rate correction curves for decrepitation of quartz. Correction: (— 40 + 80 mesh).

Several tests have been made of this relationship. For example, a number of specimens of garnet metacrysts were heated in the decrepitation apparatus. A stage of decrepitation beginning between 590° and 660°C was found in every case, and those with abundant solid inclusions gave much more vigorous decrepitation than those transparent types with only a few solid inclusions.* Similar results have

* Since this was written the common varieties of garnet have been studied in more detail, and the results are now in press (*American Mineralogist*).

been obtained using cordierite and kyanite metacrysts. This work is continuing, and the results so far obtained indicate the possibility of general use of the method for the metamorphic minerals.

The effect of pressure during crystallization is not negligible in the case of crystal inclusions, but the

Fig. 3—Relations between specific volume and diameter of bubbles and cavities in two-phase fluid inclusions, showing the approximate temperature of filling when the liquid phase is water.

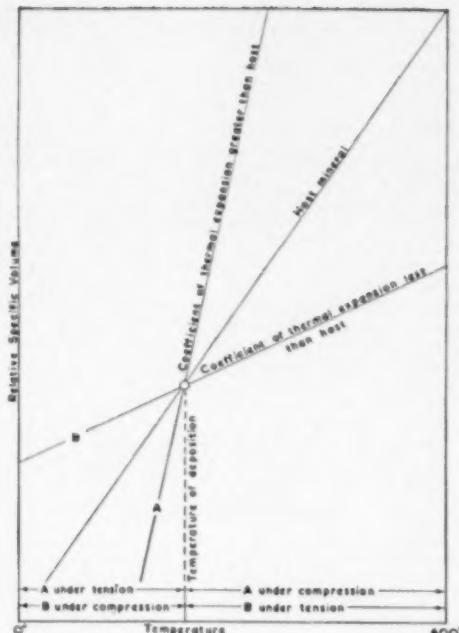
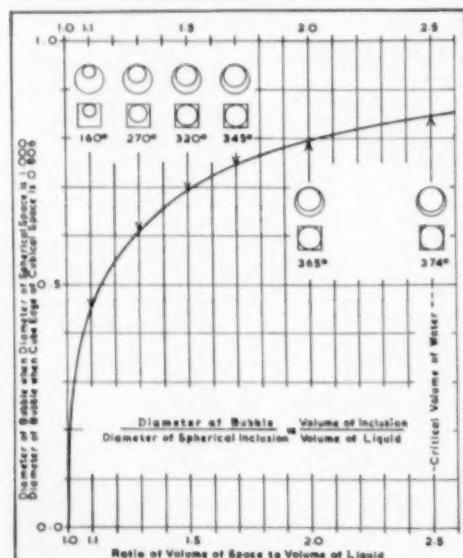


Fig. 4—Schematic diagram showing relations between temperature, volume, and compression and tension of solid inclusions in a mineral.

data for quantitative calculations are limited. For most mineral pairs, the temperature correction appears to be positive, and of the order of 10° to 20° per 1000 atm. At present all of the data of thermal expansion and compressibility of minerals are being compiled.

Another defect in the data is that while there is, for some minerals, information on the volume-temperature relations at one atmosphere, and volume-pressure relations at temperatures below 100°C, there is almost none on the volume-temperature-pressure relations over a geologically important range.

A first approximation may be made by assuming that the ratio of thermal expansion to compressibility remains constant if the volume remains constant, no matter what the temperature and pressure. On this basis, a start has been made in preparing approximate pressure-volume-temperature charts for some of the common minerals.

By superimposing two such charts, one can determine the curve of fit, if the fit can be determined at atmospheric pressure. Very much more work has to be done in this field, and probably the body of existing physical data of minerals will have to be increased.

Even though the quantitative aspects of the problem are not fully developed for use, there is now abundant evidence that most minerals begin to decrepitate at temperatures above those at which the fluid inclusions are filled. Characteristically, hydrothermal minerals give two stages of decrepitation, one due to filling of fluid inclusions and one due to an unknown cause. This has been recorded in several hundred cases, and in 28 mineral species.

Other pertinent facts are: 1—If early minerals decrepitate, because of fluid inclusions, at higher temperatures than late minerals in any one deposit, the anomalous decrepitation temperatures also are different, in the same sense, and are of the same magnitude. 2—Minerals with no visible solid inclusions do not give the anomalous decrepitation. 3—Through selection of grain size of a mineral, either the fluid inclusion decrepitation or the anomalous decrepitation may be accentuated at the expense of the other; it is more frequently found that fluid inclusion decrepitation is destroyed first when progressively finer grain sizes are used, but the reverse has been found occasionally.

Calculations Using Decrepitation Data

Ideally, if the temperature of filling of fluid inclusions and the temperature of filling of solid inclusions can be measured, and exact data are available concerning the pressure-volume-temperature relations of the homogeneous fluid, the solid inclusions, and the host mineral, then the temperature and pressure of formation of the mineral can be determined. There appear to be no limits of accuracy of the results other than the experimental.

Of course, it is necessary to be certain that fluids have neither entered nor left the fluid inclusions since the formation of the host, and similarly this applies to solid inclusions. While the body of data on fluid inclusions points to no communication between the inclusions and the boundaries of the host, and this isolation within the crystal structure framework of the host is generally considered to be reasonable, it was postulated by Kennedy in 1950 that fluids may enter and leave inclusions depending on the pressure differential. Until this can be conclusively demonstrated, it will be assumed that, although some fluid inclusions may leak because of cracks caused by deformation, those not so tapped retain the original density and composition. Similarly, unless solid diffusion can be demonstrated to have modified the amount of solid inclusions, these will be assumed not to have been altered in mass.

There is good evidence from fluid inclusions that they do not leak. For example, it is commonly found that primary inclusions in vein quartz contain liquid carbon dioxide as well as water and a gas bubble, but the secondary inclusions contain a salt crystal, water, and a very much smaller gas bubble. If the latter were derived from the former, carbon dioxide must have been removed and salt added. The two types of inclusions may be seen to lie only a few microns apart within the host crystal.

Large variations in degree of filling of fluid inclusions have been discovered in single crystals of fluorite by Twenhofel.⁶ This has been confirmed at the University of Toronto in the case of fluorite from Rosiclare. It has been found that there is a substantially lower temperature of decrepitation due to fluid inclusions in the later ruby blonde than in the earlier brown sphalerite of the Tri-State region. Also, a sequence of decrepitation temperature over a range of about 50°C is typical of crustiform zinc ore from Wisconsin. Such systematic variations do not suggest that there has been leakage of fluids into or out of inclusions.

To date, most of the temperature-pressure calculations made at the University of Toronto have been based on decrepitation data. These fall into four classes, as follows:

1—The pressure during deposition is assumed to

be constant and the variation of temperature of fluid inclusion decrepitation is taken to mean variation of temperature during deposition. The quantitative variation is obtained by the intersection of iso-volume curves and a probable geothermal gradient at the time of deposition. This method may be justified in the case of deposits such as in the Mississippi Valley, which frequently show the sequence of deposition by textures of progressive encrustation.

2—The temperature during one stage of deposition is assumed to be constant and the variation of fluid inclusion decrepitation temperature is taken to mean variation of pressure during deposition. The assumption of temperature constancy has been partially verified using the pyrite geothermometer⁷ in a few cases. This method seems to be useful in the gold quartz veins of the Canadian Shield, especially with regard to the latest low temperature stage of mineralization.

3—The temperature of deposition of pyrite as given by the thermo-electric results is combined with pyrite decrepitation results to give the pressure of deposition of the pyrite. This pressure is then assumed to be constant during deposition of the other minerals, which allows conversion of the decrepitation temperatures to deposition temperatures. In 1951 this method was used by Peach in the study of a pegmatite assemblage.

4—The anomalous decrepitation is assumed to give the temperature of deposition. Therefore when fluid inclusion decrepitation temperatures and anomalous decrepitation temperatures are combined, the pressure during deposition can be calculated. This method is being tested in several ways, one being synthesis of quartz, barite, and other minerals at known temperatures and pressures. The results are not yet conclusive.

Possible Uses of Temperature-Pressure Data

At present, mineral deposits are said to be of high, medium, or low temperature type depending on the occurrence, or absence, of certain minerals. This scheme of classification, developed by Lindgren and others, is not on a factual basis, because it has never been shown that the critical minerals are deposited in nature in restricted temperature ranges, and no reliable thermometric methods were used to establish the limits. In other words, the present scheme is a speculation rather than a reliable theory. As methods of geothermometry are devised and refined, the temperature classification of ore deposits, if such a classification is possible, will be made more factual, but a more important contribution will be a better understanding of the origin of ore deposits.

Temperature-pressure measurements should aid very greatly in determining the controls of ore deposition in veins. For example, it would be useful to know whether a fall of temperature or of pressure is more effective in depositing the various minerals. Some quantitative data on the possible effect of these two variables on the solubility of silica in water were reported by Kennedy.⁸ In this system, at high temperature, pressure is the major variable.

Another use of temperature-pressure data will be in determining the zoning of a system of veins, by relating the temperature and pressure changes during deposition of any one mineral, in three dimensions. Such relations will show the direction of flow of the mineralizing solutions, and the structural control over the flow of the solutions. This may

ultimately lead to exact predictions of depth of ore in any vein belonging to one system of mineralization.

The details of mineral paragenesis in complex ores could be resolved by exact temperature-pressure data. The order of deposition, degree of overlap, gaps in the sequence, and other factors could be determined without the use of the present subjective methods.

It would be of theoretical interest and perhaps also of some practical value to determine the genetic relations between pegmatites and hydrothermal veins. They are usually considered to be either sequential or parallel expressions of igneous activity. There are some mineralogical data suggesting a parallel history, such as both high and low temperature of filling of fluid inclusions in both pegmatite and vein minerals, but the whole matter must be restudied in detail.

The present controversy over the origin of granite could be settled if enough data on temperature of formation of igneous minerals were available. Probably the decrepitation method would detect the temperature above which misfit of solid inclusions occurs in igneous and metamorphic minerals. The shape of the resultant temperature profiles across granite bodies might discriminate between injection of a magma and metasomatic processes. The quantitative relations in the case of intrusion show that if the profile of maximum temperature in the intruded rock can be determined, then the temperature of the intruded rock and the thickness and temperature of the intrusive can be calculated.

Related to this is the possibility of detecting unexposed cupolas of intrusives in a metamorphic terrain by contouring the temperature of crystallization of one or more minerals.

In conclusion, a quotation from the writings of Sorby would be to the point: "I argue that there is no necessary connection between the size of an object and the value of a fact, and that, though the objects I have described are minute, the conclusions to be derived from the facts are great."

Acknowledgments

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Reinartz Heads 1953 AIME Nominations Slate

**LEO F. REINARTZ****For President-Elect**

Leo F. Reinartz has been nominated for the Presidency of AIME in 1954. Mr. Reinartz is now vice-president, special operating development, Armco Steel Corp. He was born in East Liverpool, Ohio, and graduated from the Carnegie Institute of Technology as metallurgical engineer. He joined Armco in 1909 as a chemist and then became open hearth foreman; assistant superintendent, open hearth dept.; superintendent, open hearth dept.; assistant general superintendent; works manager, East works; manager, Middletown div.; and assistant vice-president, successively. Mr. Reinartz has been active in many technical societies and delivered papers before several. He has been the recipient of the Alumni Award from Carnegie and holds life honorary membership in the AIME National Open Hearth Conference. One of the organizers of the National Open Hearth Conference, Mr. Reinartz was Chairman, Executive Committee (1927 to 1946) and is presently Chairman of its Finance Committee. In October 1951 he was an American Conferee at the First World Metallurgical Congress held in Detroit. An AIME member since 1925, Mr. Reinartz has been active on numerous committees of the Institute.

For Vice-Presidents

Augustus B. Kinzel has been nominated as a Vice-President and Director of AIME. Dr. Kinzel graduated from Columbia University in 1919 (A.B.); from Massachusetts Institute of Technology in 1921 (B.S. in general engineering); and in 1922 received a D.Met.Eng. from the University of Nancy where he also received the degree of Doctor of Science. Dr. Kinzel has been associated with various metallurgical units of Union Carbide & Carbon Corp. since 1926 and was chief metallurgist of its laboratories from 1931 until he assumed the presidency of the research laboratories in 1947. He is a member of various government committees and is widely known as a lecturer. He was the AIME Howe Memorial Lecturer for 1952.

**A. B. KINZEL****L. E. ELKINS**

Lloyd E. Elkins, production research director, Stanolind Oil & Gas Co., has been nominated as a Vice-President and Director, AIME. Born at Golden, Colo. in 1912, he received his degree in petroleum production engineering from the Colorado School of Mines. Following graduation he was employed by the Stanolind Oil & Gas Co. at Wink, Texas, and has risen steadily during his years with the company. In 1948 Mr. Elkins was selected to attend the advanced management program at the Harvard Graduate School of Business Administration. He has been active in the Petroleum Branch of AIME as Chairman, Mid-Continent Section (1945);

John R. Suman, Chairman of the Nominating Committee, has announced nominations for President-elect, Vice-Presidents, and Directors for 1953. As provided in Art. IX, Sec. 2, of the bylaws, 25 members or associate members may sign and transmit to the Secretary's office prior to Sept. 1 "any complete or partial ticket of nominees," should they wish other candidates to be considered.

In such instance, a letter ballot will be forwarded to all members in good standing in the United States, Canada, and Mexico, tabulating both the official ballot and any supplementary nominations. If no supplementary nominations are thus received, no letter ballot will be printed, and nominees on the official ballot shall be declared duly elected at the meeting of the Board of Directors or the Executive Committee in November.

Vice-Chairman, Petroleum Div. (1947); and Chairman, Petroleum Branch (1949). In addition to being an AIME member, Mr. Elkins belongs to the API, Engineers' Club of Tulsa (president, 1950 to 1951), Petroleum Club of Tulsa, and American Assn. of Petroleum Geologists.

For Directors

Philip D. Wilson has been nominated Director of AIME for a three year term beginning February 1953. Mr. Wilson has previously served as Chairman of the New York Section (1950) and is also a Council Delegate, New York Section. Mr. Wilson graduated from Princeton University in 1909 (B.S.) and Columbia University School of Mines in 1911 (E.M.). He was employed by various mining companies and in 1914 joined the Calumet & Arizona Mining Co. as chief geologist. He later joined The American Metal Co., Ltd., working in South America, South Africa, Europe, Cuba, Mexico, and New York City. He was also general manager

of the subsidiaries in Chile and South Africa. From 1934 to 1942 Mr. Wilson was vice-president of Pardners Mines Corp. In 1946 he joined Lehman Bros. and Lehman Mining Corp. Presently he is consulting mining engineer for this firm. Mr. Wilson is a member of various technical societies, and of several honorary societies.



P. D. WILSON



H. W. JOHNSON

Hjalmar W. Johnson, vice-president, Inland Steel Co., has been nominated as a Director of AIME for three years. He was a Director in 1950 and 1951 and served as Chairman of the Chicago Section in 1942. Born at Joliet, Ill., Mr. Johnson is a graduate of the University of Illinois (B.S.). He was employed by the Illinois Steel Co. at Joliet and later was blast furnace foreman for U.S. Steel Corp. In 1929 he joined Inland as assistant superintendent of blast furnaces. In 1930 he was promoted to superintendent of blast furnaces, and in 1942 became assistant general superintendent. Mr. Johnson was appointed staff assistant to the president in 1946 and three years later was appointed to his present position. Mr. Johnson received the J. E. Johnson, Jr. (AIME) award in 1933 and the American Iron and Steel Institute Medal in 1941.



E. L. OLIVER



E. H. ISERN

Edwin Letts Oliver, president of Oliver United Filters, Inc., has been nominated to serve as an AIME Director from 1953 to 1956. He is a Life Member of AIME and member of the Legion of Honor (class of 1902). Dr. Oliver was born in San Francisco. He graduated from the University of California in 1900. In 1903 he became surveyor and later metallurgist on the staff of the North Star Mines Co., Grass Valley, Calif. He patented a continuous automatic filter for use in the cyanide process and in 1910 opened an office under the name of

Oliver Continuous Filter Co. In 1928 Oliver United Filters, Inc. was formed by consolidation with United Filters Corp. Dr. Oliver was Chairman of the James Douglas Gold Medal Committee in 1944. In 1945 he received the honorary degree of Doctor of Laws from the University of California. He is a member of professional societies both here and abroad, and holds numerous patents in connection with filtration equipment.

Elmer Henry Isern has been nominated as an AIME Director for a term from 1953 to 1956. He is a former member of the Milling Methods Committee, 1950 member of the James Douglas Gold Medal Committee, and is present Chairman, Richards Award Committee. Mr. Isern was born in Ellinwood, Kan., June 4, 1899 and graduated from Kansas University in 1922. After graduation Mr. Isern was a research engineer for Anaconda Copper Mining Co. He joined the Eagle-Picher Mining & Smelting Co. in 1939 as superintendent of milling. In 1944 Mr. Isern was appointed vice-president and director. He was later named president, and director of the Eagle-Picher Co. He is presently vice-president and director, and general manager, mining and smelting div., the Eagle-Picher Co. Mr. Isern is an officer and member of various professional societies.

Philip Kraft, currently Vice-President of AIME and Vice-Chairman of its Executive Committee, has been again nominated Director to serve from 1953 to 1956. He was born in New York City in 1890, received his B.S. degree from Columbia College (1910), E.M. degree from Columbia School of Mines (1912), and went on to the Royal School of Mines, Berlin, for his Doctor of Engineering degree (1914). Mr. Kraft spent three years in Canada as a geologist and mining engineer, and from 1917 to 1925 was engaged in war activities, mining examinations, and consulting work. He is Director in Charge of Oil Activities of Newmont Mining Co., and president of Newmont Oil Co. In addition, he is a director of Cyprus Mines Corp., and a number of other companies engaged in the mining, oil, and gas industries. At one time or another, Mr. Kraft has served on most of the important AIME committees, not the least of which has been the Committee to Administer Endowment Fund X.

Gail Francis Moulton, presently a Director of AIME, has been renominated for a three year term beginning 1953. Born in Chicago in 1898, he graduated from the University of Chicago in 1920. Mr. Moulton has had extensive experience in the petroleum industry, served as assistant professor at University of South Dakota, and headed the petroleum section of the Illinois State Geological Survey. He was later employed by United Gas Co., Electric Bond &



PHILIP KRAFT



G. F. MOULTON

Share Co., and Ralph E. Davis, Inc. Late in 1951, he joined Rockefeller Brothers Inc. as a consultant, with offices at 30 Rockefeller Plaza, New York City. A former Vice-Chairman of the Petroleum Branch, Mr. Moulton is a prolific writer in his field, and has served on AIME committees.

Division Officers Nominated for 1953

Coal Div.: R. E. Kirk, Chairman; M. D. Cooper, Chairman-Elect; D. R. Mitchell, Secretary-Treasurer. Executive Committee; (3-year term), G. E. Keller, O. R. Lyons, and F. C. Menk.

Mineral Industry Education Div.: H. H. Power, Chairman; J. R. Van Pelt, Vice-Chairman; J. D. Forrester, Secretary. Executive Committee; (3-year term), J. C. Calhoun, Jr., D. S. Eppelsheimer, C. S. Shepard, and Allison Butts, Past Chairman, 1 year.

Minerals Beneficiation Div.: D. W. Scott, Chairman; S. D. Michaelson, Associate Chairman; Will Mitchell, Jr., Regional Vice-Chairman; M. D. Hassialis, Regional Vice-Chairman; and W. B. Stephenson, Secretary-Treasurer.

Industrial Minerals Div.: H. M. Bannerman, Chairman; S. S. Cole, Eastern Vice-Chairman; R. B. Adair, Southeastern Vice-Chairman; H. A. Schmitt, Rocky Mountain Vice-Chairman; D. B. Scott, Western Vice-Chairman; D. A. Pifer, Pacific Northwest Vice-Chairman; K. V. Lindell, Canadian Vice-Chairman; and J. J. Norton, Secretary-Treasurer. Executive Committee; (3-year term), R. C. Stephenson, J. A. Ames, W. F. Dietrich, and H. I. Smith, substitute for H. M. Bannerman.

Mineral Economics Div.: G. S. Borden, Chairman; Clayton Ball, Vice-Chairman; R. M. Foose, Vice-Chairman; S. D. Strauss, Vice-Chairman; and Franz Dykstra, Secretary-Treasurer. Executive Committee; (3-year term), Elmer Kaiser, Joseph Gillson, Andrew Crichton, and G. C. Monture for unexpired term of M. D. Harbaugh.

Mining, Geology, and Geophysics Div.: E. P. Pfeifer, Chairman; Tell Ertl, Mining Vice-Chairman; G. M. Schwartz, Geology Vice-Chairman; K. L. Cook, Geophysics Vice-Chairman; and C. M. Cooley, Secretary.

Industrial Minerals Div. and Metals Branch

Joint Pacific Northwest Meeting Is Huge Success

THE Pacific Northwest's joint meeting of the Industrial Minerals and Metals Branch in Spokane, Wash., drew 260 members, 72 students, and 30 ladies. Theme of the meeting was to acquaint men in the industry with students and younger men. The special appeal to the students was coupled with an attempt to attract young technical men from the companies located in the northwestern area. The activities of the meeting were available without charge to students. Contributions were made by the industries in the area to assist student attendance. Following the special student and faculty trip to the Trentwood rolling mills and research laboratory on Friday afternoon everyone enjoyed a complimentary dinner. A. Y. Bethune of the Sullivan Mining Co., spoke to the group on the operations of Kellogg, Idaho electrolytic zinc plant.

The Industrial Minerals Div. session was opened on Saturday morning by R. G. Vervaeke, Conference Chairman who introduced A. O. Bartell of the Raw Materials Survey, Portland, Ore. Mr. Bartell in turn introduced C. W. Sweetwood who discussed *Open-Pit Phosphate Mining*.

The Simplot Fertilizer Co. entered into active exploration of the Phosphoria formation on the Fort Hall Indian reservation in southeastern Idaho in August 1945. Open-pit mining, made possible by the flat-lying formations near the surface, began in June 1946. The main bed of 6 ft of high grade oolitic phosphate rock assaying 32.5 to 34.5 pct P_2O_5 lies below a 21 ft bed of phosphatic shales analyzing 24 pct P_2O_5 . Earth moving

machinery strips the top soil, removes the waste shale to separate dumps, then strips the two beds of ore separately and takes them to the crushing, automatic sampling and loading plant where 2000 tons per shift are handled. The high grade phosphate rock goes to the Simplot Co.'s superphosphate fertilizer plant at Pocatello, while the lower grade shale is used as electric furnace feed by the Westvaco Chemical Div. at its elemental phosphorus plant at Pocatello, Idaho.

The second paper, *Idaho Phosphorus and its Ultimate Usage*, was presented by J. G. Miller, manager, Westvaco Chemical Div., Pocatello, Idaho.

The possession of what is probably the greatest reserve of phosphate rock and phosphatic shales in the United States, combined with hydro-power developments in the same areas are the reasons that several major phosphorus producing companies are undertaking operations in the west and particularly in southeastern Idaho. Westvaco is now installing its fourth furnace at Pocatello and is supplied with raw materials by the Simplot Co. at its Gay mine. The Monsanto Chemical Co. is opening a strip mine near Soda Springs and is constructing its first electric furnace. At Silver Bow, Mont., Victor Chemical Co. is operating its first furnace and building a second. Elemental phosphorus from the electric furnaces is converted to phosphoric acid for agricultural and food products.

After a brief discussion, J. B. Myers, vice-president, Zonolite Co., Libby,

Mont., described the Libby, Mont., deposit of the Zonolite Co. which is a dominant world producer of vermiculite. The deposit is mined by open-pit techniques with Diesel-powered earth moving equipment. The mill processes 7100 tons of ore per day by means of rotary driers, crushing rolls, and 65 vibrating screens, probably the largest collection of vibrating screens in the country. Separation is accomplished by the flaky vermiculite passing through slotted screens while cubical gangue is retained.

Next J. M. Orr of the Orr Chemical & Engineering Corp., of Portland, Ore., talked on the *Industrial Utilization of Iron Oxides*. Although iron oxides usually are considered only as source materials for iron and steel, these common red and brown dirts have many other useful applications. Natural mineral pigments consist mostly of iron oxides and even the clay pigments such as ochre, sienna and umber owe their color to those oxides. Iron oxides have also found application as fillers in ceramics, cements, and rubber compounds, and as gas purifiers and catalysts in the chemical industries.

The last paper of the morning session was *Garnets in Idaho* by J. V. McDivitt, Idaho Bureau of Mines, Moscow, Idaho. Production of abrasive garnet from the alluvial deposits of Idaho has been made possible by the growth of the aluminum, aircraft and shipbuilding industries in the Pacific Northwest and California and their accompanying requirements for sand-blasting abrasives.

Idaho garnet has been found suitable for such a market. The deposits

There was an attendance of 253 people at the grand banquet held on Saturday, May 10, climaxing the conference.





The Industrial Minerals Div. session opened Saturday morning. Participants included left to right: J. M. Orr, J. B. Myers, A. O. Bartell, J. F. McDevitt, J. G. Miller, and C. W. Sweetwood.

are found in alluvial sands on Emerald Creek near Fernwood, Benewah County. The most popular size sold for \$55 a ton in 1951. This is considerably below the national average price but still higher than natural silica-type abrasives. Since the reserves of garnet sand are extensive and the market outlook good, the garnet industry in Idaho appears to be on a sound basis.

The conference was adjourned by Mr. Bartell until after lunch.

The Saturday afternoon session of the Industrial Minerals Div. was called to order by its chairman, G. H. Waterman at 2:00 pm.

Bernard W. Gamsom, director of the research and development div. of the Great Lakes Carbon Corp. at Morton Grove, Ill., presented a paper, *Industrial Carbon*.

At present, various forms of carbon are being utilized in widely diversified types of industry. Large quantities of high purity carbon are used in the production and processing of aluminum, and electric furnace alloy steels. The future demands of the supersonic aircraft industry for superior construction materials will require even greater quantities of high purity carbon for the production and processing of metals such as titanium and zirconium. Most high purity carbon used today is produced in the form of petroleum coke in large delayed coking units. Petroleum coke is also used to fabricate carbon electrodes for use in aluminum electrolytic pots.

Thermodynamic data showing the feasibility of converting graphite to

diamond was presented. Pressures in the neighborhood of 50,000 atm and temperatures in range of 1000°C are theoretically required for this transformation.

Floyd D. Robbins, University of Washington, was next with a paper *Coal Burning Steam Plant in the Northwest*.

There will be a power shortage in the Northwest which will not ease off until 1954, and even assuming completion of present hydroelectric project as planned; a safe margin will not be accumulated until 1957. This shortage can be effectively and quickly relieved by construction of one or more modern steam-generating stations. The chief advantages of steam over hydro plants are: (1) Location close to load centers, (2) more rapid construction, and (3) less than one third capital cost per unit energy produced.

James E. Dore, ceramic engineer, div. of metallurgical research, Kaiser Aluminum & Chemical Corp., spoke on *The Use of Olivine in Earthenware and Semi-Porcelain Bodies*.

The olivine (Dunite) reserves in the state of Washington are tremendous. Two principal deposits, the Cypress Island deposit, and the Twin Sisters Mountains deposit contain well over one billion tons of high quality Dunite assaying approximately 90 pct olivine.

In light of these large reserves an investigation was undertaken to determine the fluxing properties and possible use of olivine [(MgFe)₂SiO₄] in ceramic earthenware and semi-porcelain bodies, principally wall tile,



Ian Campbell, Chairman, Industrial Minerals Div., AIME, addressed the Industrial Minerals luncheon held on Saturday.

vitreous floor tile and various types of dinnerware.

The physical properties of many of the olivine bodies tested compared favorably with those of commercial wall tile, earthenware, and semi-vitreous china bodies produced in the United States.

The results of the investigation showed the possibility of utilizing, in ceramic bodies, a raw material that is available in great quantities, yet whose past use has been quite limited. They also showed that olivine can be used as a fluxing material in certain ceramic bodies.

Howard McDonald of the University of Washington discussed briefly *Hot Pressing of Clay Products*.

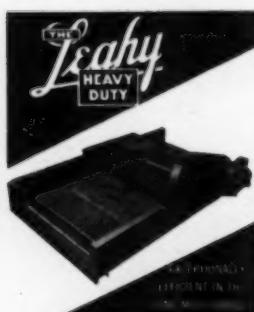
An investigation was undertaken to determine the possibility of hot press forming structural clay products from low fusion point glacial clays (fusion point 1100° to 1200°C) found in abundance in the Seattle area of the State of Washington. Results of the initial tests were encouraging and at present additional work is being done on the problem by the dept. of ceramic engineering at the University.

Ian Campbell, Chairman, Industrial Minerals Div., addressed the Industrial Minerals luncheon, briefly explaining his activities with the Institute and future plans for the division. Meeting Chairman, R. G. Vervaeke introduced F. Libby, a Director of the Institute, and G. H. Waterman, next Chairman of the Industrial Minerals meeting. The luncheon was attended by 181 persons.

Climax to the conference was the joint dinner on Saturday with 253 in attendance. Commissioner Lawson of Spokane expressed his pleasure to the group and invited all to return. Chairman of the Columbia Section, Professor Staley was toastmaster.

The Women's Auxiliary at Spokane had a brunch on Saturday, at which a local dancing group gave a series of their selections. Some 70 ladies attended.

This joint venture of the Metals Branch and Industrial Minerals Div. demonstrated the advantages of this type of meeting in the Northwest. Plans are underway for a similar affair next year, in view of the results this year.



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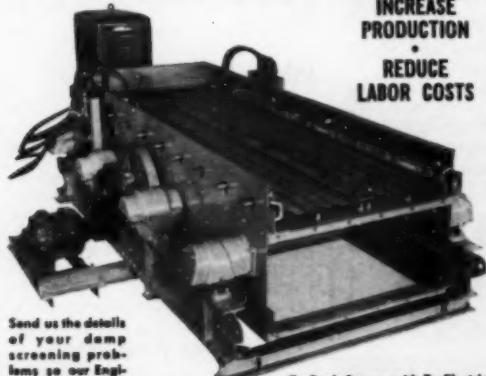
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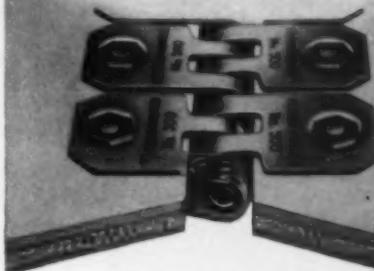
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R. Beals Joins Staff

Rixford Beals joined the staff of MINING ENGINEERING as assistant editor on June 1. Mr. Beals is 27, a native San Franciscan, and a B.S. graduate in process metallurgy from the University of California in 1950. He has had milling experience in Mexico and more recently as a research engineer in beneficiation for the Jones & Laughlin Steel Corp. at Neogaule, Mich.

1954 New York Annual Meeting Hotel Reserved

Final confirmation of Statler Hotel, New York, as convention headquarters for the AIME Annual Meeting, Feb. 14 to 18, 1954, and of the Waldorf-Astoria Hotel for the banquet on February 17, was given at the meeting of the Executive and Finance Committees on May 21. The 1953 Annual Meeting will be held at the Statler Hotel, Los Angeles, February 15 to 19.

UPADI Meeting Planned

Plans have been virtually completed for the second meeting of UPADI (Union Panamericana de Asociaciones de Ingenieros) in New Orleans, August 25 to 30. The first meeting was held in Brazil in 1949. Headquarters will be at Tulane University, where sleeping and restaurant facilities will be available at ex-

tremely modest prices. The St. Charles is reserving rooms for those who prefer a hotel. Engineers' Joint Council has been asked to send delegates from its constituent societies. W. H. Carson and Fred T. Agthe, with Sherwin F. Kelly as alternate, will represent AIME through EJC. Business meetings of the delegates will be held on Monday am and pm, August 25; Wednesday am and pm; and Friday am. Plenary sessions will be held on Tuesday devoted to: (1) General philosophy of engineering education and immediate postgraduate training of engineers; and (2) problems and plans for the expansion of engineering education. Thursday will be devoted to a trip about the port and other excursions, and numerous luncheons and dinners have been arranged. Luis Giannattasio, of Montevideo, Uruguay, is president of UPADI. J. M. Todd is vice-president and is in charge of local arrangements. His address is 217 N. Peters St., New Orleans 16, La. AIME members other than delegates are also invited to the meeting, and should complete their plans through Mr. Todd. A ladies' program is also planned.

Honorary Member Dies

A vacancy in the roll of Honorary Members of the Institute, limited to twenty living members, has been caused by the death in England, on May 7, of C. McDermid.

Dues Voting Ballot Mailed

A referendum on dues is currently being conducted by the Institute. A statement of the Board's position in the matter and a ballot for voting was mailed to all paid-up AIME members in the United States, Canada, and Mexico on June 16, returnable to the Secretary's office not later than July 15. All members who receive a ballot are urged to vote for a continuance of the present scale of dues, so that present Institute services can be fully maintained, and, it is hoped, expanded in the future.

Revise Handling of Junior Applications

Revision of the former directive regarding handling of applications for Junior Membership in the Institute, from those who have served in the armed forces, was voted at the meeting of the Executive and Finance Committees on May 21. The new ruling, effective immediately, is as follows: "Subject to approval of the Admissions Committee in individual cases, all veterans who have served in the armed forces of the United States or friendly countries who apply for Junior Membership will be allowed a credit of one year on the entrance age limit of 30 years for each year of military service up to three years. Any portion of total continuous military service in excess of six months shall constitute a full year credit; similarly, any portion less than six months shall not be considered. Applicants attaining Junior Membership under this regulation shall be allowed a similar credit beyond the 33-year age limit for changing status to Associate Member or Member."

Pike's Peak Subsection Recognized Formally

Following its organization several months ago, the new Pike's Peak Subsection of the Colorado Section was formally recognized and approved by the Board at its meeting on April 16. The Subsection's territory includes the counties of El Paso, Fremont, Huerfano, Las Animas, Pueblo, and Teller.

Back Issues Requested

Demand for the January, February, and March issues, 1952, of MINING ENGINEERING exceeds the supply. The Institute will pay 50¢ apiece for salable copies of these issues returned to AIME headquarters. It will only be necessary to put the name and address of the sender on the wrapper when returning copies; a check will then be sent.

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—Coming Events—

July 1-Sept. 30, Centennial of Engineering, Chicago.

Aug. 25-29, Oak Ridge Summer Symposium, Oak Ridge, Tenn.

Sept. 3-6, AIME, Industrial Minerals Div., annual fall regional meeting, Chicago.

Sept. 3-6, AIME, fall meeting, Palmer House, Chicago.

Sept. 3-13, AIME, Chicago Section, Centennial of Engineering, Chicago.

Sept. 5-6, Engineers' Council for Professional Development, annual meeting, Hotel Sherman, Chicago.

Sept. 10-12, Porcelain Enamel Institute, annual shop forum, University of Illinois, Palmer House, Chicago.

Sept. 11-13, American Institute of Chemical Engineers, Palmer House, Chicago, Ill.

Sept. 18, AIME, Utah Section, Newhouse Hotel, Salt Lake City.

Sept. 22-25, American Mining Congress, Metal and Nonmetallic Mining Convention and Exposition, public auditorium, Denver.

Sept. 23-25, Institution of Mining and Metallurgy, symposium on mineral dressing, Royal School of Mines, London.

Sept. 26, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Oct. 2, AIME, National Open Hearth, Southern Ohio Section, Deshler-Wallick Hotel, Columbus, Ohio.

Oct. 10, AIME, Eastern Section, National Open Hearth Steel Committee, Harwick Hotel, Philadelphia.

Oct. 19-22, AIME, Institute of Metals Div., fall meeting with National Metal Congress, Hotel Adelphia, Philadelphia.

Oct. 24, Illinois Mining Institute, annual meeting, Hotel Abraham Lincoln, Springfield, Ill.

Oct. 28, Assoc. of Consulting Chemists and Chemical Engineers, Inc., annual symposium, Hotel Belmont Plaza, New York.

Oct. 30-31, AIME, Fuel Conference, Coal Div.; ASME, Fuel Div., Bellevue-Stratford, Philadelphia.

Nov. 4, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Nov. 6-8, New Mexico Mining Assn. and International Mining Days, joint convention, Alvarado Hotel, El Paso.

Nov. 18, AIME, Buffalo Section, National Open Hearth Steel Committee, Hotel Statler, Buffalo.

Nov. 19, American Mining Congress Coal Div. Conference, Wm. Penn Hotel, Pittsburgh.

Nov. 20-21, American Society for Quality Control, mid-west conference, Claypool Hotel, Indianapolis.

Dec. 3, American Mining Congress, annual membership meeting, University Club, New York.

Dec. 4-6, AIME, Electric Steel Furnace Conference, Hotel William Penn, Pittsburgh.

Dec. 7-10, American Institute of Chemical Engineers, annual meeting, Hotels Cleveland and Carter, Cleveland.

Dec. 8, AIME, Arizona Section, all-day meeting, Tucson.

Feb. 16-19, 1953, AIME, annual meeting, Statler Hotel, Los Angeles.

Mar. 16-20, National Assn. of Corrosion Engineers, annual conference and exhibition, Hotel Sherman, Chicago.

Apr. 11-May 23, Empire Mining and Metallurgical Congress, Australia-New Zealand.

Apr. 20-22, AIME, National Open Hearth and Blast Furnace, Coke Oven and Raw Materials Conference, Hotel Statler, Buffalo.

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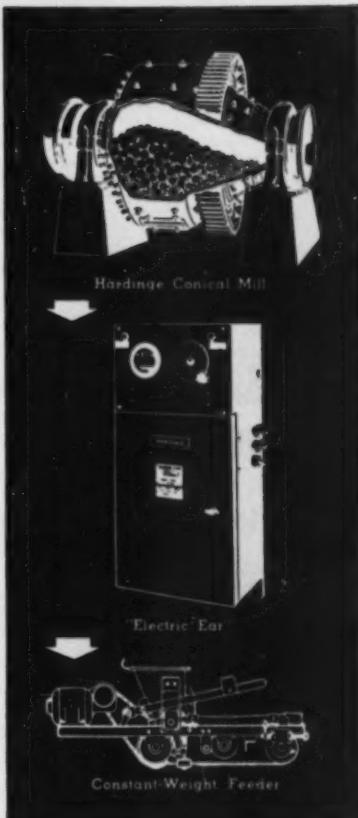
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AIME Fall Meeting and Engineering Centennial Celebration Plans Progress

Plans for the fall meeting of the AIME, to be held in conjunction with the Centennial of Engineering—marking the 100th anniversary of the Society of Civil Engineers—indicate that the Chicago gathering will be one of the most significant in Institute history. Headquarters for the six divisions represented will be the Palmer House.

Twenty technical sessions will be held from September 3 to 6, with papers of industry-wide impact to be presented. The papers will follow the theme of the celebration—a century of engineering progress. The MBD will start the ball rolling with morning and afternoon sessions Thursday, September 4. A luncheon also will be held. MBD has scheduled morning and afternoon sessions for the following day as well.

MGGD, Iron and Steel, and the Coal Div., will hold sessions Friday afternoon. The Industrial Minerals Div. plans an executive meeting, 5 pm, Friday. Geology Subdivision is slated for morning and afternoon sessions Saturday. The Coal Div. will meet again Saturday morning.

The Industrial Minerals Div. session on Friday will be concerned with mineral aggregates and resources in the Chicago area. The first session of the Geology Subdivision Friday afternoon, will be centered around brown iron ore in Alabama, Georgia, Minnesota, Missouri, Texas, and Virginia. A regional summary of brown iron ore occurrences, production and utilization will follow. The morning and afternoon sessions Saturday will deal with plans of State Geological Surveys of Minnesota, Michigan, Ohio, Wisconsin, Illinois, and Indiana. A joint luncheon with the Mining Subdivision will be held between sessions.

The Chicago Section will be host at a dinner Friday evening, preceded by an AIME business meeting. An all-Institute dinner-dance is listed as the high point Saturday night. AIME Board of Directors convene Sunday, September 7, at 2 pm.

Thus far, 44 scientific societies have signified that they will participate in the 10-day celebration, scheduled to last until September 13. At least 15 foreign countries will par-

ticipate officially. The Centennial celebration is expected to be the greatest convocation of engineers the world has ever seen.

A symposium will be presented on *Groundwater in Industry* on Saturday morning and afternoon. Papers to be presented are: *A Geographical Investigation of Glacial Deposits near Anderson, Ind.* by Maurice Briggs, W. J. Wayne; *Sonor Sediment Studies in Shore Areas of Lake Michigan at Chicago* by W. O. Smith; *Geology of Industrial Groundwater Supplies in Illinois* by F. C. Foley; *An Application of Interference Methods to a Problem of Brine Disposal in the Dundee Formation of the Michigan Basin* by John Ferris; *The Industrial Application of Groundwater Recharge by Wells* by M. L. Brashears, and *Large Industrial Water Supplies by Induced Filtration* by F. H. Klaer, Jr.

Indiana Geological Survey will conduct a field trip September 3, with visits to the Grisman Sand Co., the Manley Sand Co., and the Box Sand Co. A stop will be made at the Indiana Dune Sand State Park. Another field trip has been arranged for September 4.

The Minerals Industry Symposium will be conducted September 8, under the Chairmanship of Clyde Williams, director of Battelle Memorial Institute.

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THE DRIFT OF THINGS

by Edward H. Robie

Engineers' Centennial

THIS summer, in Chicago, will be celebrated the "Centennial of Engineering" and half a hundred engineering societies will have meetings of one kind or another in the two weeks following Labor Day. It is really the 100th anniversary of the founding of the American Society of Civil Engineers. Centennial of Engineering is merely a convenient label to put on the celebration of 100 years of engineering progress in this country since the ASCE was founded. Engineering, of course, is much older than is thus indicated—thousands of years older. But Americans have a penchant for dramatizing progress by celebrating assumed anniversaries. Four years ago a special 3¢ stamp was issued on which a Brahma chicken was prominently displayed, with the legend, "1848-1948. Centennial of the American Poultry Industry." We feel reasonably sure that the first dozen eggs was sold considerably earlier than that.

Until a hundred or so years ago engineers were generally classified as either military or civil. Apparently a group of civil engineers met for the first time in Augusta, Ga. but no records were kept and the first meeting of which we have definite knowledge was at Barnum's Hotel in Baltimore, Feb. 11, 1839. Forty engineers were present and they decided to form a society. Among the aims of these engineers was "the greatest amount of useful effect at the smallest cost," which is as good a slogan for the engineer of today as it was 113 years ago. It was mentioned that the existence and prosperity of the society depended in no small degree on "the personal conduct and exertions" of the members. "Talents and respectability are preferable to numbers... from too easy and promiscuous admission, unavoidable, and not infrequently incurable, inconveniences perplex most societies."

The name American Society of Civil Engineers was selected. It was recommended that "architects and eminent machinists" be admitted to only associate membership. The founding committee recommended that every Member and Associate be required "to produce to the Society at least one unpublished communication in each year, or present a scientific book, map, plan, or model not already in the possession of the Society under penalty of \$10." Apparently the society was too exclusive and the penalty for the unproductive member a bit too steep, ten bucks being what it was in those days, so the society died a-borning. An effort was, however, made to set up four engineering societies on a geographical basis, with one covering New England and New York; the second, Pennsylvania, New Jersey, Maryland, Delaware, and Virginia; the third all the states south of Kentucky and Virginia; and lastly "Kentucky and the Northwestern States." Something along this line was accomplished when the Boston Society of Civil Engineers was founded in 1848.

Efforts to organize a national society were finally successful in 1852 when the American Society of Civil Engineers and Architects was founded. There was but one grade of membership, to which were eligible "Civil, Geological, Mining, and Mechanical Engineers, Architects, and other persons who, by profession, are interested in the advancement of science." Those educators of the present day who take a dim view of the curricula labeled "geological engineering" can thus see

that geological engineers were at least given early recognition.

In 1853 the Society held eight meetings, with an average attendance of six, and in all only 14 different members came to the meetings. In 1854 only six meetings were held, and attendance was less than in 1853 so resident dues (for those within 50 miles of New York) were reduced from \$10 to \$5 and non-resident dues from \$5 to \$3. This was done to "render membership less onerous, and with the hope that by so doing new members might be induced to seek a connection with the Society... the labors of the members more than their money is wanted to make the Society useful."

The Society had no headquarters so it was proposed to rent a room convenient to the office of some member who might be willing to supervise it, the annual rental of the room not to exceed \$250, and the cost of furnishing not more than \$150.

After its meeting on Mar. 2, 1855 the new Society was dormant for 12 long years, during which period the Civil War was fought. It came to life, with two rooms as headquarters in downtown New York, in 1867. Dues were put back up to \$10 and \$5, and the assets of the Society were \$1592.07. The next year the words "and Architects" were deleted from the Society's name, but it remained a society for all engineers even after the mining engineers formed the AIME in 1871. In 1855 a member of the Society asked "whether any Transactions of the Society have been published or intended to be" (grammar was evidently not pure even in those days) but it was not until 1872 that the Civils published their first volume of Transactions. That was only one year before the first volume of AIME Transactions was published. A members' badge was not adopted until 1884 though the AIME had previously adopted one, and the American Society of Mechanical Engineers, founded in 1880, likewise. The Electricals did not form a separate society until 1884, and used the Civils quarters for several years. The Chemicals did not branch off on their own until 1908.

On Feb. 14, 1903 Andrew Carnegie wrote the following letter:

"Gentlemen of the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, and the Engineers' Club: It will give me great pleasure to give, say, one million dollars to erect a suitable Union Building for you all, as the same may be needed. With best wishes, Truly yours, Andrew Carnegie." The societies were required to purchase suitable property on which to erect the building. The final amount that Mr. Carnegie gave was \$1,050,000, and the present Engineering Societies Building was dedicated on Apr. 16 and 17, 1907. The Civils did not move in and become one of the four "Founder Societies" until about ten years later.

We are indebted to a history of the ASCE prepared by Edward C. Thoma for most of the above information. With the present building soon to celebrate its 50th anniversary, what we engineers now need is another Andrew Carnegie. Unfortunately the political climate is not now so favorable for accumulating large fortunes which may be available for such purposes as it was a half century ago.

Personals

John Elliot Allen has been made acting head, dept. of geology, New Mexico Institute of Mining and Technology, Socorro, N. Mex. He had been associate professor of geology.

Robert B. Anderson has accepted a position with the U. S. Steel Co., Gary, W. Va., as assistant to the superintendent, No. 2 mine.



D. L. ARCHIBALD

Donald L. Archibald has joined the sales dept. of the Ellicott Machine Corp., Baltimore. He formerly had been associated with the Joy Mfg. Co., St. Louis.

J. C. Boswell has been appointed manager of the Fairbanks dept., United Smelting Refining & Mining Co. **J. B. Metcalfe** has been appointed assistant to the president. **G. Howard LeFevre** was elected vice-president and general manager of metal sales and **R. N. Hunt**, vice-president and chief geologist was elected a director. **R. B. Earling**, vice-president and general manager of Alaskan operations, has retired but will continue to serve on the board of directors. **J. D. Crawford** has been appointed general manager of Alaskan operations.

Otis H. Banes has been made superintendent of acid, roasting in the cadmium, waelz-oxide, and zinc carbonate dept., Fairmont City plant, American Zinc Co. of Illinois, East St. Louis, Ill.

Herman E. Bakken, vice-president and general manager of the Aluminum Ore Co., is now in Pittsburgh. He had been at St. Louis.

Robert S. Bailey, manager of the Eastern District, Western Machinery Co., New York is now in Jeffersonville, Ind.

Werner J. Bergmann is research engineer with the Aluminum Research Laboratories, New Kensington, Pa.

Ihsan Ruhi Berent has become president of the Engineering Consolidated Contractors, Ankara, Turkey.

Robert A. Blake, mill superintendent, American Smelting & Refining Co. has been transferred from Mike Horse, Mont. to Colville, Wash.

John J. Borkert, Jr. is now employed as a control engineer for the Kennecott Copper Corp., Ray mines div., Ray, Ariz.

Orrin T. Barrett has accepted the position of superintendent of the central coal preparation plant of the Brazilian National Steel Co., Tubarao, Santa Catarina. He recently resigned as mining engineer with the U. S. Bureau of Mines, coal preparation section, Pittsburgh.

Thomas C. Baker is now connected with Canadian Exploration Ltd., San Francisco, a subsidiary of Placer Development Co.

Andre L. Brichtant formerly with the U. N. Mission to Libya, has joined the Kennecott Copper Corp., New York.

William H. Burgin is now field engineer with the Kennecott Copper Corp., Denver.

J. L. Black has accepted the position of field engineer with the Enterprise Exploration Co. Pty., Ltd., Broken Hill, New South Wales, Australia. He had been associated with the Zinc Corp. Ltd.

Furman H. Burge, Jr. recently joined the Oliver Iron Mining div., U. S. Steel Co., Duluth, Minn.

Fred C. Bond was awarded a medal in recognition of distinguished achievement in the field of mineral engineering by the board of trustees, Colorado School of Mines.



F. C. BOND

Edward J. Bottomley has joined the Wesson Coal Mining Corp., Boonville, Ind., as general superintendent.

Ernest V. Bowman has become plant manager for the Winding Gulf Collieries, Goodwill, W. Va.



A. L. BARD

A. L. Bard has been appointed manager, grinding media sales, Sheffield Steel Corp., Kansas City, Mo. Mr. Bard has been associated with Sheffield since 1938 and was formerly in charge of engineering sales and development of grinding media.

Allison Butts, professor of electro-metallurgy, Lehigh University, was named head of the dept. of metallurgy.

Donald M. Cannon has resigned from Pacific Mining Services, Ltd., Vancouver, B. C.

C. D. Clarke, formerly superintendent of the Yauricocha mine, Cerro de Pasco Corp., Peru, has been transferred to the mine at Cerro de Pasco, as superintendent.

William David Coolidge was awarded the first K. C. L. medal by Columbia University for advancing the science of tungsten. He received the medal "for his conception and development of a method for obtaining ductile metallic tungsten to the benefit of mankind." Dr. Coolidge is director emeritus of the General Electric Research Laboratory, Schenectady and retired in 1944 as a vice-president of the company.

Douglas C. Corner is presently in Australia for the Goodman Mfg. Co., and is making his headquarters with John Carruthers & Co., Sydney.

John Cannizzo is now with the United Paracale Mining Co., Camarines Norte, Philippine Islands.

Ben B. Chomiak has resigned as engineer for the Colorado Fuel & Iron Allen coal mine, Weston, Colo. He has accepted a position as junior engineer for the American Smelting & Refining Co., Parral, Chihuahua, Mexico.

Carril E. Dobbin received the honorary degree of Doctor of Engineering from the Colorado School of Mines.

Gregory S. Devine has been elected a vice-president of Truax-Traer Coal Co. and will continue to head Binkley Coal Sales.

Wendell W. Fertig is now deputy chief of psychological warfare for the Dept. of the Army, Washington, D. C.

Robert B. Fulton has accepted a position as mining engineer for the Newmont Mining Corp., New York.

Harold B. Foxhall is now geologist for the Dow Chemical Co., geological dept., Houston.

John James Forbes is now mill foreman for the Estella Mines Ltd., Wasa, B. C.

J. W. George has been transferred to New York by Union Carbide & Carbon Corp.

James B. Girod has been made industrial engineer for the U. S. Steel Co., coal div., Uniontown, Pa.

Thomas E. Gillingham, Jr. has joined the Atomic Energy Commission as staff geologist, New York.

James K. Grunig is now geologist for the U. S. Geological Survey, mineral deposits branch, Washington, D. C.



S. E. HOLLISTER

S. E. Hollister, associated with the Southwestern Engineering Co., Los Angeles, will serve as mining and metallurgical consultant in Japan.

Robert Turner Howard is no longer associated with Black, Sivalls & Bryson, Kansas City, Mo.

Joao G. Haenel has been made technical assistant to the director, export

and import dept., Banco do Brasil, Sao Paulo.



D. J. KRAMM

Douglas J. Kramm has been appointed district sales manager in charge of the western district, Traylor Engineering & Mfg. Co. His headquarters will be in San Francisco.

C. P. Keegel has resigned as manager of the Compania Minera Aguas Fria and is returning to Las Vegas, Nev.

Arthur J. Kerr is now with the Kerr Engineering Sales Co., Pittsburgh.

A. Irving Levorsen, who served as professor in geology at Stamford Uni-

versity for seven years, has resigned from the post and returned to Tulsa.

Donald W. Lindgren is now in Puerto Rico for the West Indies Mining Corp., as geologist.

Carrel B. Larson, formerly assistant general manager, Patino Mines & Enterprises, Catavi, Bolivia, is now chief of the South American branch, foreign expansion div. DMPA., Washington, D. C.

L. H. Lange, vice-president and manager, metallurgical dept., Galigher Co., Salt Lake City, has returned from a two months consulting trip abroad.

N. B. Melcher has been appointed chief of the ferrous metals and alloys branch of the U. S. Bureau of Mines' minerals div.

P. I. A. Narayanan has returned to India after a visit to various ore dressing laboratories and plants in Australia.

Ennis A. Naeve has accepted a position with the Bennett-Perry-Thomas Engineering Co., Oak Hill, West Va.

John M. Norlin, W. S. Tyler Co., has been made sales engineer and is now located in Birmingham.

Harry S. Nelson is now employed as an assistant contract engineer with the Frey engineering dept., Koppers Co., Inc.

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WILMOT CONVEYOR BULLETIN 502

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P. J. Shonan and **R. P. Full** have announced the reopening of their consulting firm in Salt Lake City. **Richard P. Gerwels** is associated with them. Dr. Shonan is a past chairman of the Mining, Geology and Geophysics Div., AIME and is currently a member of the Mining Branch Council. Mr. Full is a member of the Papers and Program Committee. Mr. Gerwels was chief mining engineer for the Bayard dept., U. S. Smelting, Refining & Mining Co., Bayard, N. Mex.

Howard G. Schoenike has resigned from the Hanna Development Co., and is now employed by the Baroid sales div., National Lead Co., Hous-

ton. He is doing geological work in the production dept.

Dexter A. Tutein is president of the Tutein Corp., New York.

W. C. Thompson, former assistant sales manager has been made special representative, A. P. Green Fire Brick Co., Mexico, Mo.

D. S. Vasquez S. M. is now metallurgist foreman for the Cia. Minerade Guatemala, Cogan, Guatemala. He was formerly assistant to metallurgist, Braden Copper Co., Chile.

Ralph A. Watson is now associated with the Great Northern Railway Co., Spokane.

Obituaries

Appreciation of Fred Wise

by Fred Searls, Jr.

Something of the zest and vigor of recent Colorado mineral production passed on May 1, when Fred Wise laid down his tools, and turned in his check to the Timekeeper, who keeps the little book on all of us who dig the ore that long ago he put in the hard rocks of the West.

Fred Wise was born in a crosscut, as the miners say, for Oct. 31, 1906 found his native Virginia City still a mining camp. He learned to break rock while his father, Alex Wise, and the latter's partner, Roy Hardy, were operating Flowery Ridge—a poverty-stricken relative of the nearby Comstock Lode—on a margin so thin that a broken shovel handle put the operation in the red. From such environment and the Virginia City schools, Fred went on to Stanford University where he graduated in January 1929, as shift boss for the Goldfields and worked at Fresno.

There he stayed a year, but his father missed his help and he returned in 1930 to work at Flowery Ridge and then in 1933 at the Beebe mine in Placer County, Calif., where Alex had become impressed with the ill-fated Hadsel mill.

From the Beebe, Fred went to the Original Amador as superintendent at the age of 29. At the Amador, he learned the hard way about the missing maternal instincts of the Mother Lode, for he had the responsibility of the operation during the violent strike of 1934 and the mine fire in 1936. He acquitted himself so well that we tried, when he left Amador County, to hire him for superintendent of the Zeibright mine. But simultaneously Roy Hardy, his father's former partner, offered him the Getchell, which he then managed until late in 1942.

Wise joined the Navy in March 1943 and in June went to Europe as a lieutenant in the Seabees. He headed, as officer in charge, the demolition squad that led the invasion of Sicily, and was officially commended for action at Toulon. He was discharged Nov. 4, 1945. While in the Navy, he married Marjorie Mumm in Washington and is survived by her and two children.

Shortly after discharge from the Navy, Wise entered the employ of Newmont Mining Corp. He advanced rapidly and in 1946 became manager of the Idarado mine and in 1950 also of the Resurrection mine at Leadville, directing as well other exploration efforts of Newmont in the Rocky Mountain area. We know and have known that he had only started, and the loss is deeply felt by our whole organization.

At the shaft collar, or where the men in diggers mount the trains,

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FRED WISE

there will yet be an occasional hard hat turn to catch his voice. If his language was rough, it was spiced with the kindly humor that miners like; and behind the "Wise" cracks, there was often sound and helpful comment. To us, it still seems "the boss will be around."

Charles Henry White

An appreciation by A. W. Stickney

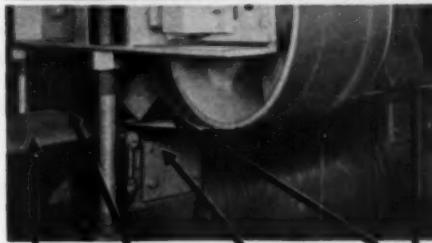
On Monday the 17th of March Charles Henry White, my esteemed friend for over forty years, passed away in an Oakland, Calif. hospital following a cerebral hemorrhage. Although he had reached his 86th year he was working on the manuscript of a publication on the genesis of ore deposits until shortly prior to his death.

Born in North Carolina on Aug. 13, 1865, Mr. White received his early education at Vanderbilt University and the University of North Carolina. In 1897 he obtained his S.B. (magna cum laude) from Harvard University and his A.M. in 1902. From 1905 to 1917 he was assistant professor and then professor in mining and metallurgy at Harvard. Early in 1918 he was assigned to the Watertown Arsenal as Captain of Ordnance U. S. Army and on his discharge in 1919 entered the practice of mining geology in San Francisco. In addition to work for several mining companies in this country and Mexico he did consulting work for foreign companies in Australia, Africa, Yugoslavia, and Bulgaria. During World War II he gave a series of lectures at the San Francisco Armory.

Mr. White belonged to several professional, scientific, and educational societies. In addition to being a member of the American Institute of Mining and Metallurgical Engineers for 52 years, from which he received the gold medal of the Legion of Honor, he was a member of the Society of Economic Geologists, Le Conte Geological Club of California, California Academy of

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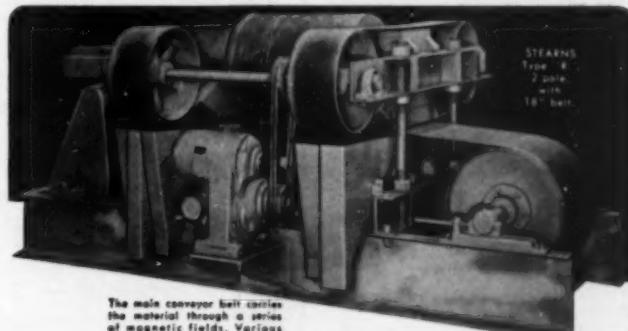
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Sciences, Seismological Society of America, Fellow of the American Geographical Society and the Royal Geographical Society. He was also a member of the Commonwealth Club of San Francisco, Harvard Travellers, and Phi Beta Kappa.

Mr. White, with Bohuslav Stoces, was the author of a textbook entitled *Structural Geology*. He contributed a number of articles to technical and scientific journals dealing especially with copper deposits and the abyssal theory of ore genesis. His professional work on disseminated copper deposits led to formulating guides to such ore bodies by a study of the leached croppings. In later years he became convinced that there was no genetic relationship between the ore deposited rocks.

It is of a mining district and the association. Throughout his life he was truly a scholar. As a teacher, and later as a professional consultant, he gave patiently his friendly advice from his fund of knowledge. He was a man of high integrity and at all times a gentleman whose calm dignity, kindness and exemplary humor were an inspiration to his associates. In his quiet, unassuming manner he enjoyed the many pleasant things in life which made him a gracious host to his friends. He was always conservative in his manner of living which probably contributed to his long span of his professional life.

His widow, Mrs. Marjorie Mills White of San Francisco survives him.

Billy F. Edwards (Member 1951) was killed by lightning in August 1951. He had been a student at the Louisiana State University.

NECROLOGY

Date Elected	Name	Date of Death
1920	Wilton P. Alderson	February 1951
1911	E. J. Carlyle	April 27, 1952
1911	J. E. S. Clark	April 23, 1952
1950	James A. Creighton	Unknown
1948	Irvan Earl Curtis	Oct. 12, 1951
1913	Theodore F. Foss	Unknown
1914	John G. Gandy	May 1, 1952
1916	Robert L. Hallett	May 10, 1952
1915	John H. Hastings	Unknown
1919	Leslie D. Hawkrige	Apr. 21, 1952
1928	Dudley A. Hoover	Apr. 3, 1952
1930	Russell C. Johnson	Dec. 3, 1951
1921	C. McDermid	May 7, 1952
1919	Arthur J. McLaughlin	January 1952
1959	Joseph H. Rodgers	April 23, 1952
1926	Persifer G. Spilsbury	May 7, 1952
1914	George B. Waterhouse	May 10, 1952
1944	Clark White	Unknown
1938	Fred Wise	May 1, 1952
1944	C. William Witt	Unknown

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The Institute desires to extend the privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

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A-M)

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S-J)

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J-M)

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S-J)

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Hillsdale—Schlottman, Alfred W. (J) (C/S—
S-J)

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Uniontown—Marsh, William J. (J)

Tennessee
Ducktown—Annand, Albert D. (M) (R. C/S—
J-M)

Ducktown—Lee-Aston, R. (J) (R. C/S—S-J)

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Salt Lake City—Stevens, Victor L. (M) (R.
C/S—J-M)

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Wisconsin
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S-J)

Australia
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Belgium
Brussels—DeSmael, Albert (M)

Bolivia
Cataca—Weiss, Herbert M. (M)

Canada
Whitehorse—Hoggan, John E. F. (J) (R. C/S—
S-J)

England
London—Wrobel, Stanislaw A. (M)

Kenya
Nairobi—Jewitt, Walter (M)

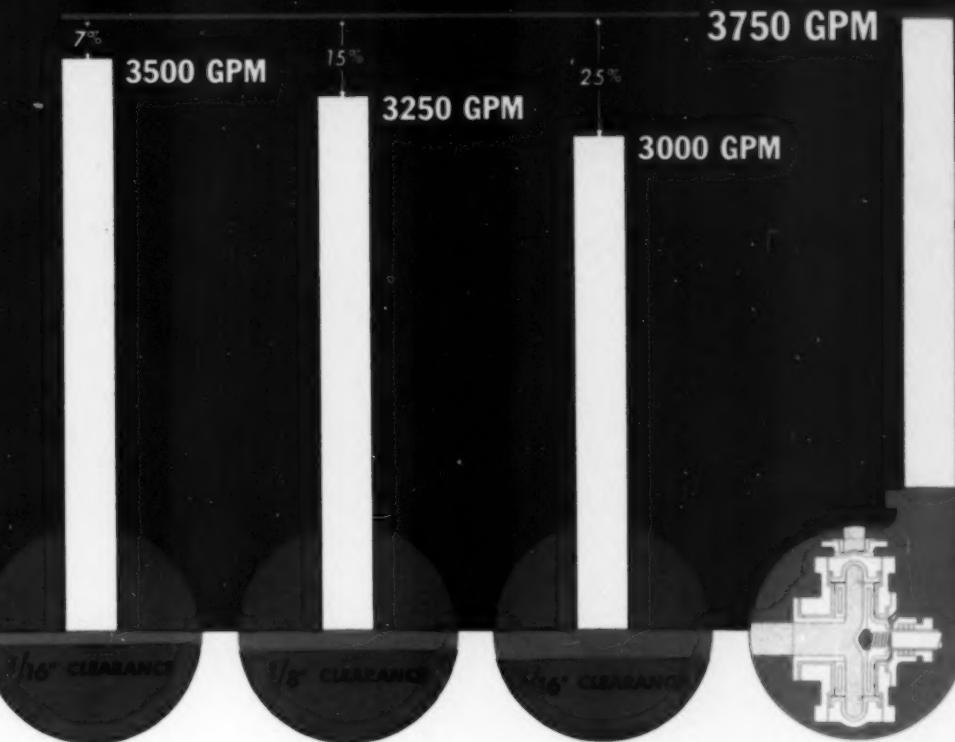
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Parral—Nelson, Alex E. (J) (C/S—S-J)

South America
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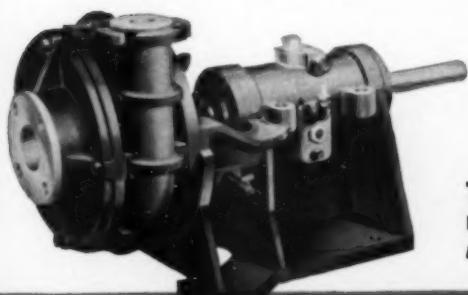


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